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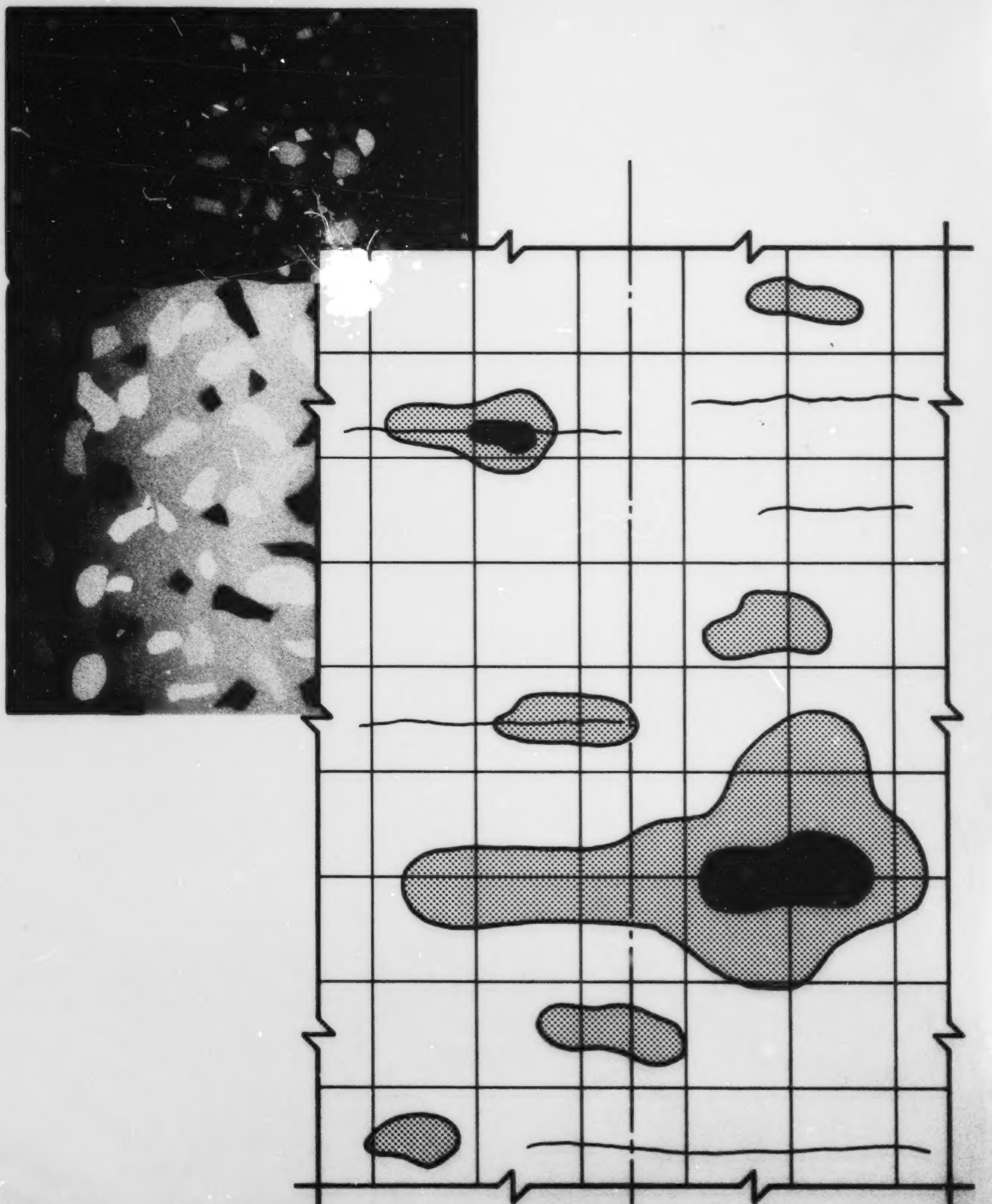
Branch

Bridge Deck Rehabilitation Manual

Part One: Condition Surveys



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Bridge Deck Rehabilitation Manual

Part One: Condition Surveys

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1/ INTRODUCTION

1.1/ Scope and Purpose

This manual covers the essential procedures in the preparation of contract documents for the rehabilitation of concrete deck slabs of highway bridges. The manual is written primarily for use by the staff of the Ministry's Structural Sections. It is also suitable for use by municipalities and consulting engineers engaged in bridge deck rehabilitation.

The scope of the manual is determined by those activities normally considered to be part of the planning and design process. It ends when the tender documents for the rehabilitation contract are complete. The purpose of the rehabilitation methods described is to prolong the life of the deck by 10 years or more. Repairs to other parts of the structure are addressed in so far as the repair of these components is usually included in a bridge deck rehabilitation contract. Temporary repairs such as patching and epoxy injection are not discussed. The evaluation of the structural capacity of bridge decks, by load testing or analysis, is also beyond the scope of this manual.

Bridge deck rehabilitation consists of four essential steps:

- survey of the condition of the deck;
- planning, including selection of method;
- design, including preparation of the contract documents; and
- construction.

The first step is covered in Part 1 of this manual. Part 2 contains the procedures involved in steps two and three. A supplement to the manual contains typical special provisions and references to contracts for many of the activities in bridge deck rehabilitation contracts. It is anticipated that as these special provisions are incorporated in Ministry standard specifications, the supplement will not be required and it will be withdrawn.

The information contained in this manual is based largely on Ministry Research and Development reports published in the period 1975 - 1982, as well as the Ministry's experience in preparing and administering bridge deck rehabilitation contracts during that period. No attempt has been made to summarize research results and the interested reader is referred to the Ministry's research reports and the numerous references listed in them.

Modern bridge deck rehabilitation presents a considerable challenge to engineers, contractors, material suppliers and inspection staff. The degree of skill required to carry out the surveys, planning, design and construction is often greater than that needed for new construction. The reward for work well done is the effective use of resources in maintaining structures which are safe and in good repair. This manual, coupled with sound engineering judgement throughout the progress of the work, has been written to produce the optimum in deck rehabilitation using state-of-the-art technology.

2/ COMMON DEFECTS

2.1/ Introduction

The service environment for highway structures results in very harsh exposure conditions for all materials in common usage. Defects in both Portland cement and bituminous concretes, steel and other components such as joints and bearings are therefore common. The purpose of this Section is to describe briefly the most common defects which will be found in condition surveys of highway structures in Ontario. For more detailed information, the reader is referred to NCHRP Synthesis of Highway Practice No. 57 "Durability of Concrete Bridge Decks" (TRB, 1979) and the Ministry's Bridge Inspection Manual. A series of photographs of common defects in Portland cement construction is given in the report of ACI Committee 201 "Guide for Making a Condition Survey of Concrete in Service".

2.2/ Concrete

2.2.1/ Cracking

A crack is defined as an incomplete separation into one or more parts with or without a space between them. Cracks are common in concrete because of its low tensile strength and relatively large volume changes, which result from changes in humidity and temperature. The significance of cracks is dependent on their origin, and whether the length and width is increasing with time.

The following is a summary of the most common causes of cracking and the characteristics of the cracks resulting from each:

• **Plastic Shrinkage**	Often, though not necessarily, pattern cracking results from rapid drying of the concrete in its plastic state. The cracks are often wide but shallow.
• **Drying Shrinkage**	Cracks result from drying of the concrete after it has hardened. These are usually finer and deeper than plastic shrinkage cracks and have a random orientation.
• **Settlement Cracks**	These may be of any orientation and width, ranging from fine cracks above the reinforcement, which result from the settlement of formwork, to wide cracks in supporting members due to foundation settlement.
• **Structural Cracks**	Except for fine cracks controlled by the provision of reinforcement, structural cracks usually result from the differences between assumed and actual stress distribution. Width will vary, although orientation will often be well defined; examples are diagonal cracks in the acute corners of severely skewed decks and the wide longitudinal cracks over the voids in some post-tensioned structures.
• **Reactive Aggregates**	Usually, map cracking (a closely spaced network of cracks) increasing in magnitude and intensity, with time.

• **Corrosion of Reinforcement**	This type of crack is usually associated with shallow cover and is located directly above the reinforcement. Width increases with time and rust stains may be associated with the cracks. Crack terminates at reinforcement.
• **Freeze-Thaw**	Closely-spaced cracks parallel to the concrete surface (and therefore only visible in cores) are usually associated with scaling. The cracks closest to the surface are the widest.

In making a condition survey, the following characteristics of cracks are reported: location, orientation and width. The depth of cracks is also important. However, this can only be determined by coring or when the crack is full depth, and consequently visible on the opposite surface of a member. The location of the cracks is either shown on a scale plan (as required for an exposed concrete bridge deck) or described (as required in the Component Inspection Form). The following terms are used to describe the orientation of a crack with respect to the major axis of a member:

- longitudinal,
- transverse,
- diagonal, and
- random.

For the requirements of this manual, crack widths are estimated (not measured) according to the following scale.

narrow	(N)	less than 0.3 mm
medium	(M)	0.3 to 1.0 mm
wide	(W)	greater than 1.0 mm

While the widths of cracks on the concrete surface are to be reported, care is needed to ensure that widths are not overestimated. Ravelled edges, or moisture associated with the crack, may make the crack more visible and appear to be wider than it is. Conversely, narrow cracks are difficult to identify on concrete surfaces which are either uniformly wet or dry.

2.2.2/ Scaling

Scaling is the flaking of the surface mortar of the concrete. As the scaling progresses, coarse aggregate is exposed and eventually loosened. Scaling results from the repeated freezing of concrete which is critically saturated with water; the presence of de-icing salts aggravates scaling. It is usually indicative of inadequate air entrainment.

Scaling may also occur in a weak surface layer, which results from poor finishing and curing practices.
The areas of scaling, which are either described or shown on a scale plan, are classified according to the following scale:

Severity of Scaling	Depth, mm	Characteristic Appearance
light	0 to 5	coarse aggregate not exposed
medium	6 to 10	coarse aggregate exposed
heavy	11 to 25	coarse aggregate projecting from the surface
severe	over 25	loss of coarse aggregate particles

Scaling is most common in older structures and especially in asphalt-covered deck slabs. The relationship between the age of bridges and the use of air entrainment and protective treatments in Ontario is summarized in Appendix B.

2.2.3/ Corrosion of Embedded Reinforcement

Corrosion is the electrochemical degradation of steel in concrete. It occurs when oxygen and moisture are present, and the passivity of the steel is destroyed by either carbonation of the concrete or by the presence of chloride ions at the steel surface. These conditions are common in highway structures. As the steel corrodes, it expands and causes a delamination (which is a separation along a plane parallel to the surface of the concrete), usually located at, or near, the level of the reinforcement. As the corrosion processes continue, delaminations eventually become detached from the concrete body resulting in a spall. Cracks are not necessary for the occurrence of corrosion since the chloride ions will even penetrate uncracked, high quality concrete. Depending upon the amount of cover and degree of corrosion, cracks may, or may not, be present within or at the extremities of delaminated areas.

Corrosion activity is measured by comparing the potential of the reinforcing steel with the potential of a standard reference cell. Where a copper-copper sulphate is used, the numerical values are indicative of conditions as listed below.

- If potentials over an area are numerically less than -0.20 V, there is a greater than 90% probability that no reinforcing steel corrosion is occurring in that area at the time of measurement.
- If the potentials over an area are in the range -0.20 V to -0.35 V, corrosion activity of the reinforcing steel in that area is uncertain.
- If potentials over an area are numerically greater than -0.35 V, there is a greater than 90% probability that reinforcing steel corrosion is occurring in that area at the time of measurement.

Field procedures for potential measurements and detecting areas of delamination are given in Section 4.

2.2.4/ Other Defects

2.2.4.1/ Honeycombing and Air Pockets

Defects originating at the time of construction may be present in formed surfaces. In this category, the two most common deficiencies are air pockets and honeycombing. Air pockets result from insufficient vibration. Honeycombing occurs when the mortar does not fill the spaces between the coarse aggregate particles. Honeycombing may be caused by either incomplete consolidation or leakage of the mortar at a joint in the formwork.

2.2.4.2/ Popouts

Popouts are shallow depressions which result from the breaking away of the concrete surface due to internal pressure. These are most frequently associated with frost susceptible aggregates. Chert particles in the gravels from southwestern Ontario are the most common example.

2.2.4.3/ Wear

Excessive wear may be present on some concrete surfaces exposed to traffic abrasion, especially in wheel-track areas. Wear can sometimes be difficult to distinguish from grinding (used at the time of construction to achieve an acceptable surface tolerance) and light scaling.

2.2.4.4/ Erosion

Ice movement or, in the case of rivers with a high bedload, abrasion by solid particles causes erosion of the concrete surfaces of abutments or piers exposed to rivers or lakes.

2.2.4.5/ Surface Deposits

The most common types of surface deposit are efflorescence and exudation. Efflorescence is a deposit of salts, usually white, which results from the flow of a solution from within the concrete to the surface where the water evaporates. Exudation is the solid or gel-like component of material discharged at an opening in the concrete surface. Both efflorescence or exudation may be associated with cracks, though this is not always the case.

2.3/ Waterproofing and Bituminous Concrete

Although the occurrence of defects in the waterproofing layer and the bituminous surfacing is of interest, normal aging of these components results in replacement at approximately 15 to 20 year intervals. Consequently, less emphasis is placed on defects in these components than is given to reinforced and prestressed concrete elements of the structure. However, any defects in the surfacing which may be indicative of deterioration in the concrete deck slab are of particular importance.

The following is a brief summary of some waterproofing and bituminous concrete defects that may be encountered. A more comprehensive list of defects and their causes is contained in MTC's "Manual for Condition Rating of Flexible Pavements (Distress Manifestations)".

2.3.1/ Waterproofing

Defects in waterproofing can only be detected by selective removal of the bituminous surfacing and examination of the waterproofing. The most common defects are:

- inadequate thickness at the time of construction;
- excessive thickness resulting in shoving of the pavement;
- lack of adhesion to the deck slab;
- moisture present beneath the waterproofing;
- penetration of the membrane by aggregate particles from the bituminous overlay;
- migration of the membrane into the bituminous overlay;
- rotting of the fibreglass in some fibreglass-asphalt emulsion systems; and
- embrittlement, especially in some mastics.

2.3.2/ Bituminous Concrete

Cracks extending for part of, or the full depth of, the bituminous concrete are common. These cracks may result from a number of causes, including:

- tensile stresses in the surfacing at low temperatures;
- deformation of the bituminous concrete under traffic;
- reflection cracks from cracks or other defects in the concrete deck slab;
- delamination between bituminous layers;
- original cold joint at the time of placing the surfacing; and
- poor construction practices.

The orientation of the cracks varies widely. Narrow cracks in the bituminous overlay are usually not important to the performance of a concrete bridge deck. For condition survey purposes, only cracks wider than 3 mm wide are recorded.

The loss of coarse aggregates is another form of distress in pavements. Some possible causes are:

- lack of bond between particles and mortar due to inadequate coating or to stripping under the action of water;
- fracture of the particles through load or natural causes, allowing the loosened pieces to be picked out by traffic action; and
- disintegration or delamination of particles such as chert.

Ravelling is a progressive loss of pavement materials from the surface downward or edge inward which results from:

- clay coated aggregate particles;
- insufficient asphalt content;
- poor adhesion of asphalt binder to aggregate;
- poor compaction; and
- asphalt hardening due to age.

Rippling, shoving and rutting of the bituminous overlay may result with mixes of low stability, or where the thickness of the waterproofing is excessive. This results in the partial displacement of the bituminous overlay (a washboard surface) which is most common where heavy truck traffic must make braking, accelerating or turning manoeuvres.

Although not a material defect, inadequate or excessive thickness of bituminous concrete may be a contributing factor to cracking, ravelling, rippling, shoving or rutting.

2.4/ Components

Within the context of this manual, the condition of components is documented only in so far as future rehabilitation of the structure is affected. It is therefore not necessary to describe the condition of the components in detail. However, major defects which either require that the component itself be repaired or have an adverse effect upon the performance of other parts of the structure must be identified.

The following is a summary of the more common defects in joints, drains, bearings, and steel and timber components. More detail is given in the Bridge Inspection Manual. Defects in concrete components are described in Section 2.2.

2.4.1/ Joints

The more common defects in joints are listed below.

- Gaps outside the normal operating range:
  - a gap less than the minimum may indicate unanticipated (irreversible) movement of the structure or movement of the approach pavement which may have also damaged the ballast wall.
  - a gap exceeding the maximum may indicate unanticipated (irreversible) movement of the structure or tilt or movement of the abutments. (Maximum and minimum gaps for currently approved joints are given in DS141, "Designated Sources for Joint Assembly, Bridge Expansion".)
- leakage through sealed joints (in extreme cases, the slope protection may be undermined or have slipped);
- loose hardware and anchorages;
- excessive accumulation of debris in the joint;
- deterioration of the concrete or asphalt adjacent to the joint; and
- clogging or breakdown of troughs and plumbing systems, usually associated with open joints.

2.4.2/ Drains

The more common defects in drains are listed below:

- plugged with debris;
- too short, allowing surface run-off to discharge on other components;
- poor location resulting in ponding on the deck surface, or the discharge causing ponding or erosion beneath the structure; and
- drains too high or too low with respect to the deck surface.

2.4.3/ Bearings

The more common defects in bearings are:

- excessive corrosion resulting in bearing being seized;
- excessive tilt;
- evidence of unequal loading on any bearing and between bearings;
- loose or missing components;
- broken, bent or corroded retaining pins;
- cracks, delaminations and excessive bulging in elastomeric bearings; and
- squeezing out of the TFE element in sliding bearings.

2.4.4/ Steel Components

The more common defects in steel components are:

- paint chipping and peeling;
- corrosion on painted steel;
- laminar or excessive corrosion on weathering (ACR) steel;
- misalignment;
- accumulation of debris; and
- loose or missing fasteners.

2.4.5/ Timber Components

The more common defects in timber components are:

- rot;
- checking;
- loose or misaligned connections; and
- split or broken elements.

3/ PLANNING THE CONDITION SURVEY

3.1/ Levels of Surveys

The level of the survey is established by the way in which the information on the condition of the structure is to be used and this in turn controls the detail to which the inspection and/or testing is carried out. It should be noted that the general and detailed deck condition survey discussed in this manual differ from the condition survey defined in the OHBDC. The purpose of the surveys described herein is to document the deterioration in the structure rather than measure the mechanical properties of the materials which influence the load carrying capacity of the bridge.

3.1.1/ Routine Inspections

Within MTC, the first level of a survey is the biennial structural inspection carried out by personnel in the MTC Regional Structural Sections and District Offices. All elements of the structure are visually inspected, photographs are taken of deteriorated areas and a report is prepared. These reports are used to establish priorities for future repairs to structures on a regional basis and the need for a more detailed inspection.

3.1.2/ General Deck Condition Survey

A general deck condition survey is normally carried out on several structures when more detailed information is needed than is available. The information is then used to establish priorities for rehabilitating structures. The scope of the work is a visual survey with a minimum amount of physical testing necessary to establish the overall condition of the structure. The physical testing will normally consist of taking core and sawn samples. The information obtained from a general survey is not sufficient to prepare a rehabilitation contract.

3.1.3/ Detailed Deck Condition Survey

A detailed deck condition survey is carried out only after a deck has been scheduled for rehabilitation. The data collected is then used to establish the repair method, and in the preparation of contract documents for the rehabilitation project. If the data collected is to be meaningful, the condition survey should be carried out no more than two years prior to the proposed rehabilitation; one year is preferable.

This manual deals only with the detailed deck condition survey. A Standard Consultant's Agreement has been prepared for this work and is contained in Appendix A. This agreement is only to be used when the decision to undertake rehabilitation has already been made and it is known that the work will primarily involve rehabilitation of the concrete deck slab. The agreement is not to be used, unless suitably modified, where:

- an evaluation of load carrying capacity is required;
- the need for rehabilitation has not yet been determined;
- the need for replacement can be established by a more effective means;
- the deterioration is largely in components other than the deck slab.

The agreement is suitable for application to most structures having a concrete deck slab. However there are some structural types, such as adjacent concrete box beams without a structural slab, or composite steel and concrete or timber and concrete decks, for which the agreement must be modified before use.

3.2/ Organization

This part of Section 3 outlines briefly the basic requirements for reference plans, traffic control, manpower, grid layout and equipment for carrying out a detailed condition survey. This information is intended for use as a guide; the manpower and equipment will vary with each individual project.

3.2.1/ Plans

Obtain the latest version of the existing structure plans and review them for the following criteria:

- size and type of structure;
- unusual features in the design;
- structure location and topography at the site;
- direction and size of top reinforcing steel bars in deck slab for covermeter check;
- obtain and review previous maintenance reports;
- identify utility ducts if present;
- locate stressing cables and void tubes on post-tensioned structures;
- year of construction–relationship between age and possible deterioration as detailed in Appendix B; and
- determine the number of joints–establish the number of separate grounds that will be required for potential measurements (a separate ground is required for each discontinuous slab).

3.2.2/ Site Visit

A preliminary visit to the site can be very useful in establishing:

- traffic control requirements;
- general indications of the condition of the structure which can be used to establish the approximate duration of the survey and crew size;
- the extent of deterioration and the need to arrange for a boat, ladder, bucket truck or other equipment to inspect the soffit; and
- any unusual problems.

3.2.3/ Traffic Control

- Traffic control for condition surveys shall be in accordance with MTC's "Traffic Control Manual for Roadway Work Operations".
- The responsibility for provision of traffic protection and control will vary from region to region but should be identified in the Standard Consultant's Agreement (Appendix A). The decision regarding the responsibility for traffic control will influence manpower requirements.
- If there are any time constraints involved in carrying out the survey (e.g., work permissible in off-peak hours only), they will be identified in the Consultant's Agreement and will influence manpower requirements.
- Determine the order and number of lane closures required to carry out the survey in the most expedient manner and with the least disruption to traffic.

3.2.4/ Manpower

- In general, the crew will consist of a supervisor and two to four crew members, not including traffic control or a core drill or saw operator.
- If traffic control is to be provided by the survey crew, the crew size will have to be increased to suit.
- On large structures, the crew size can be increased for mapping cracks and operating additional covermeters or half cells.

3.2.5/ Grid Layout

- When carrying out a condition survey, data is collected with reference to grid lines marked out on the deck surface. A 1.5 m x 1.5 m grid is used on exposed concrete decks and a 3 m x 3 m grid on asphalt-covered decks.
- On structures with complex geometry, considerable planning is required to lay out grid lines to ensure compatability with proposed lane closures and traffic control. A proposed grid layout should be established using existing structure drawings prior to going to the site.
- Reference lines are required for both the longitudinal and transverse grid lines. A curb line is generally suitable as a longitudinal reference line. If the joints are straight and run from one side of the deck to the other they are suitable as transverse reference lines.

Longitudinal grid lines run parallel to the longitudinal reference line, but the 1.5 m or 3 m line spacing is measured perpendicular to the longitudinal reference line. The first longitudinal grid line is normally placed 0.25 to 0.5 m from the curb, wall or median barrier. To lay out transverse grid lines the measurements are made parallel to the longitudinal reference line and the grid lines run parallel to the transverse reference line. Examples of grid layouts for the more common deck configurations is shown in Figure 1.

The grid lines as described are plotted on a base plan of the deck and copies of that plan are used to show deterioration to the deck surface, corrosion potentials, concrete cover and soffit deterioration.

3.2.6/ Equipment

A list of equipment required to carry out a detailed deck condition survey is contained in Appendix C of this manual.

3.2.7/ Forms

Appendix A contains examples of the forms which are to be completed as part of the detailed deck condition survey. These include:

- Structure Identification Sheet;
- Survey Summary Sheet for Exposed Concrete Decks;
- Survey Summary Sheet for Asphalt-Covered Decks;
- Component Inspection Form—Page 1;
- Component Inspection Form—Page 2;
- Survey Equipment and Calibration Procedures;
- Core Log for Exposed Concrete Bridge Decks;
- Core Log for Asphalt-Covered Bridge Decks; and
- Sawn Asphalt Sample Log.

In addition to the above-mentioned forms, letter-size grid sheets of the structure have to be prepared. Each grid sheet includes the longitudinal and transverse grid lines and covers a convenient portion of the deck. Copies of the grid sheets are used in the field to record data collected on surface deterioration, asphalt depths, half cell potentials, concrete cover to reinforcement and soffit deterioration.

Figure 1/ Typical Grid Layouts

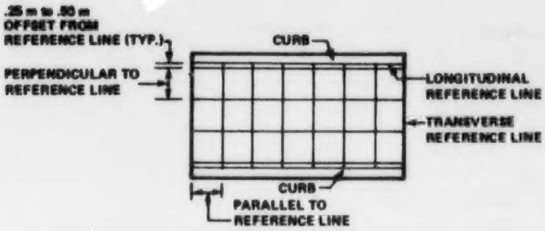

.25 m to .50 m
OFFSET FROM
REFERENCE LINE (TYP.)
PERPENDICULAR TO
REFERENCE LINE
CURB
LONGITUDINAL
REFERENCE LINE
TRANSVERSE
REFERENCE LINE
CURB
PARALLEL TO
REFERENCE LINE

Figure a/ No Skew—Straight Alignment

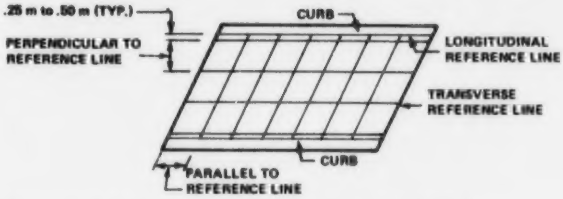

.25 m to .50 m (TYP.)
PERPENDICULAR TO
REFERENCE LINE
CURB
LONGITUDINAL
REFERENCE LINE
TRANSVERSE
REFERENCE LINE
CURB
PARALLEL TO
REFERENCE LINE

Figure b/ Skew—Straight Alignment

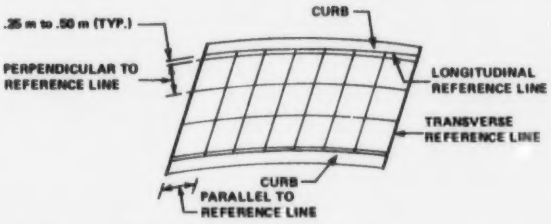

CURB
.25 m to .50 m (TYP.)
PERPENDICULAR TO
REFERENCE LINE
LONGITUDINAL
REFERENCE LINE
TRANSVERSE
REFERENCE LINE
CURB
PARALLEL TO
REFERENCE LINE

Figure c/ Skew—Curved Alignment

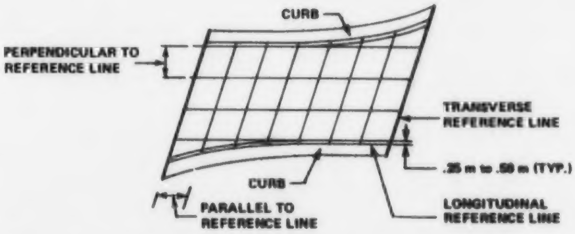

CURB
PERPENDICULAR TO
REFERENCE LINE
TRANSVERSE
REFERENCE LINE
.25 m to .50 m (TYP.)
CURB
PARALLEL TO
REFERENCE LINE
LONGITUDINAL
REFERENCE LINE

Figure d/ Skew—Straight Alignment With Ramps

4/ FIELD PROCEDURES

4.1/ Grid Layout

The marking of grid points on the deck is normally carried out by three persons. Two persons are required to hold the tape while the third marks the grid points. The first requirement will be to confirm that the longitudinal and transverse control lines chosen from the drawings are acceptable. The measuring tape is placed on the deck parallel to, and 0.25 to 0.5 m from, the longitudinal control line. The grid points are then marked along the tape at 1.5 m or 3 m increments starting at the transverse control line.

A pencil crayon (Keel) should be used in marking grid points. The use of spray paint is prohibited.

4.2/ Test Methods

4.2.1/ Delaminations

Delaminations in concrete are detected by striking the surface and noting the change in sound being emitted. Several methods, using such tools as hammers, steel rods, chains and, more recently, electronic acoustical devices have been used for detecting delaminations in concrete.

The chain drag method has been found to be the most suitable for detecting delaminations on the top surface of bridge decks. The chain is moved from side to side in a swinging motion along the surface of the concrete. A change in the normal ringing sound to that of a dull sound would normally indicate that a delaminated area has been encountered. A heavy chain (2.2 kg/m with 50 mm links) has proved to be most suitable, especially in areas where there is interference from traffic noise.

Delaminated areas are normally marked directly on the deck surface using a pencil crayon. The areas are then measured (size and location) and recorded on the appropriate grid sheet.

The chain drag is generally used in detecting delaminations on exposed concrete surfaces only. It can be useful, though, as a quick method of identifying potentially defective areas in asphalt-covered decks, that might require further investigation. However, these areas are not measured and recorded.

4.2.2/ Corrosion Potential

The corrosion potential survey is used to measure corrosion activity at the time of the test and is carried out in accordance with the requirements of ASTM C876. A copper-copper sulphate half cell is most commonly used because it is rugged and stable. Since corrosion activity is a function of temperature, readings should not be taken when the temperature is lower than 5°C. Even then, the readings may not be indicative of the corrosion activity which occurs in the deck at higher temperatures. For the results to be accurate, the deck must be surface dry at the time of the test.

It is important that the ground connection is positive and that the ground is connected directly to the reinforcing steel or to a component that is in direct contact with the reinforcing steel. A separate ground is required for each portion of the slab that is not continuous.

On decks with a concrete surface the survey is carried out on a 1.5 m x 1.5 m grid. On asphalt-covered decks a 15 mm diameter hole has to be drilled through the asphalt and any waterproofing material to make contact with the concrete. In order to reduce the work required for drilling holes, asphalt-covered decks are surveyed on a 3.0 m x 3.0 m grid. Drilling dust is removed from the holes before the wetting solution is added to take the reading.

Asphalt depths are measured in the holes drilled for corrosion potential tests. It is recognized that an exact measurement is not possible because of the difficulty in defining when contact is made between the drill bit and the deck surface. However, small errors are not significant in relation to the large number of readings taken.

If the difference in potential readings at adjacent grid points is greater than -0.15 V additional readings must be taken at midpoints until the difference is reduced to -0.15 V.

4.2.3/ Concrete Cover

The concrete cover over the top layer of reinforcing steel is measured using a pachometer (covermeter) which is a device for measuring thickness. A pachometer measures disturbance in a magnetic field and the magnitude of the disturbance is proportional to the size of the bar and its distance from the probe. The cover to the top bar in the top mat is measured nearest the grid point or by taking an average of the bars on either side of the grid point.

The existing structure drawings should be checked to determine orientation and the size of top bars (note if bar size is constant). Also, ensure that the covermeter is operated with the probe oriented parallel to the top bars. If the structural drawings are not available and the orientation of the top bars is not known, the probe is rotated at several locations until a sharply defined minimum reading (maximum deflection) is obtained. This indicates the probe is directly above a bar, and the orientation of the bar coincides with the longitudinal axis of the probe.

On decks with concrete surfaces the cover is measured on a 3 m x 3 m grid. On decks with an asphalt surface, cover is measured in areas where sawn samples have been removed.

Longitudinal and transverse reinforcing steel is tied together to form a relatively rigid mat. As a result any significant change in the cover readings at adjacent points should be viewed with suspicion and additional readings taken to confirm the results.

4.2.4/ Coring

The drilling and subsequent examination of cores can provide a measure of the quality of concrete in the bridge deck. The core size is normally 100 mm in diameter. The number of cores required, which is a function of the deck area and its condition, is given in the agreement. The lower number in the range applies to decks in good condition and the higher number applies to decks in poor condition. More cores are taken from asphalt covered decks because it is more difficult to establish the condition of the concrete deck slab.

Some cores are required in areas where deterioration might be expected ie., near curbs, at cracks in asphalt, in areas of poor drainage, and at cracks or wet spots in the deck soffit.

However, it is also intended that the cores be representative of the condition of the deck slab. Consequently cores should also be taken from areas of the deck which are thought to be sound. Sound cores will, in any event, be required for physical testing. At least one core, free from reinforcing steel, should be used for compression testing. If the structure has a thin slab deck, one core should be taken full depth.

Cores should be taken after completion of the non-destructive testing because they can be especially useful if taken in areas where contradictory data has been obtained. Consideration should be given to taking cores in areas of the deck having wide cracks or unusual crack patterns. This sequence of operations also prevents water from the coring operation interfering with the half cell potential measurements.

When coring a deck with an asphalt surface which has a poor bond between concrete and asphalt, it is advisable to remove the asphalt from the core bit before drilling the deck slab so that the asphalt is not broken inside the bit. Where asphalt thickness is in excess of 100 mm, it is sometimes necessary, in order to retrieve the concrete core, to remove a 150 mm core from the asphalt prior to taking the 100 mm core in the concrete.

If the concrete being cored is in poor condition and is broken into several fragments the juxtaposition of the pieces should be recorded, by either a sketch or identification of individual pieces so that the core can be pieced together in the laboratory.

Each core should be given a number which identifies the structure and its location in the structure. The location of the cores should be noted directly on the grid sheets and the core logs.

Prior to repairing the core holes, the sides of the hole must be cleaned and any water removed. Core holes are then repaired by tamping a stiff mixture of an approved repair material in layers until the hole is filled level with the deck surface. On decks that have a waterproofing membrane, a disc of preformed waterproofing material is placed on the concrete. Cold mix asphalt is then compacted to be slightly above the bituminous surface.

In some cases, the Ministry may require a core to be taken in the approach pavement to confirm the existence of a concrete approach slab or from the sidewalk or curb to determine the quality of the bond with the deck slab. Where these cores are required, this will be stated in the agreement and information on utility ducts provided. The cores are to be included in the Core Log but no physical testing is required. The core from the approach slab need not be retained but those from curbs or sidewalks must be retained until advised by the Ministry.

4.2.5/ Sawn Samples

Sawn samples are removed from asphalt-covered decks to establish the condition of the concrete deck, the presence and condition of waterproofing materials, and to check the cover to reinforcing steel. Sawn samples provide considerably more information on the degree and type of deterioration than cores. Consequently sawn samples should be concentrated in areas of suspected deterioration. They can be especially useful in investigating the condition of the deck slab at cracks in the asphalt or above areas of deterioration in the soffit. The size of the sawn samples must be a minimum 250 mm x 250 mm. At least one sample is to be removed from the area adjacent to the curb.

The samples must be removed by dry sawing in order to determine if, and how much moisture is present beneath the asphalt.

The condition of the concrete and waterproofing are of greater significance than the condition of the asphalt. Consequently, photographs should be taken to show clearly the condition of the concrete surface. This may involve cleaning the concrete surface of bituminous residue. The types of waterproofing used by the Ministry are summarized in Appendix B.

Sawn sample areas should be repaired by compacting cold-mix asphalt to slightly above the level of the bituminous surfacing. On decks which have been waterproofed, a piece of waterproofing material is cut to fit the removed area and mastic is used to fix the membrane to the deck surface.

4.3/ Equipment Calibration

Standard forms are provided to document the data required for calibration of the equipment used for checking concrete cover and corrosion activity. A description of equipment used and the temperatures at the time of the test is also required.

4.3.1/ Pachometer or Covermeter

A battery check is made at the start and end of the test. On some instruments the calibration tends to drift while in use. Therefore, the instrument is calibrated at a core hole where a bar location is known or at an exposed bar, and checked periodically (as per Equipment Calibration Form). This procedure will also identify if there are magnetic particles in the concrete for which a correction factor must be derived.

4.3.2/ Corrosion Activity

A battery check is made at the start of the test. The location of the ground, the method of connecting to ground and the resistance measured to ground should be recorded. At least five potential measurements should be checked at the beginning and the end of the test, and each time a new ground is used. Duplicate readings should differ by no more than 0.02 V. Where greater differences are recorded the test should be repeated.

4.4/ Visual Inspection and Recording of Data

All data recorded in the field should be complete, legible and unambiguous to avoid errors in preparing the final report and required drawings.

Cracks, and areas of scaling and spalling on the deck, curbs and sidewalks are recorded on the field grid sheets.

The width of cracks is estimated, not measured. On exposed concrete decks the cracks are classified according to the scale given in Section 2.2. and the letter W(wide), M(medium) or N(narrow) is noted beside each crack on the grid sheet. On asphalt-covered decks only those cracks wider than 3 mm are recorded.

Scaled and spalled areas are measured and their size and location recorded with respect to the grid lines. The depth of scaling is classified according to the scale given in Section 2.2.

The deck soffit must be inspected, and areas of deterioration or defects including significant cracks, spalling, wet spots, leaching, honeycombing and exposed reinforcement noted on the grid sheets. The location of void drains, where present, is shown on the same sheets. In some cases, access to the deck soffit will be difficult. However, where significant deterioration exists or is suspected every effort must be made to complete this part of the inspection. This may involve the use of a boat, ladder or bucket truck to gain access.

All data that is required will be specified in the agreement.

Data from half cell, cover and delamination surveys should be recorded on field grid sheets in such a manner that the final drawings can be prepared by a drafter.

Sawn sample logs should be completed in the field. It is also good practice to complete the identification, dimensions and remarks section of the core log forms, since this reduces the possiblity of errors in identifying cores.

4.5/ Component Inspection

It is the intent of this section of the survey that the condition of components be recorded primarily to determine if repair of the components should be included in the deck rehabilitation contract. This means that the type and extent of the deterioration is recorded on the Component Inspection Forms but physical testing is not required.

Information required on the standard forms will normally be recorded directly on a field copy of the forms and later transcribed. This should minimize the possibility of omissions. It is intended that unusual features or items, which cannot be adequately covered on the form, be described in the space allotted for remarks. Typical comments are given in the sample reports in Section 7.

In general, the forms are self-explanatory, however some problems may be encountered when completing the forms in the field. The potential problem areas are addressed below.

- The dimensions of each joint are required even where there is no armour or seal because new joints are usually installed as part of the rehabilitation contract. All joint gaps should be measured perpendicular to the line of the joint.
- It is important to note that where the joint has been paved over, it is the gap between the deck and the ballast wall which is required, not the width of the crack in the asphalt. In order to measure the gap, the asphalt must be removed at the curbs and at the centreline of the highway.
  There may be exceptional circumstances, such as the use of sliding plates where it is not possible to measure the joint gap. However, the engineer should be aware of this situation from his review of the plans and should make a note on the form in the section for remarks.
- The deck temperature shall be taken 50 mm below the surface on exposed concrete decks and at the asphalt-concrete interface on asphalt-covered decks. The ambient temperature should be the shade temperature, usually taken below the structure.
- The most common types of joints and bearings are described in the MTC Bridge Inspection Manual.
- Information on the drains is required because extensions often have to be fabricated for installation during a rehabilitation contract. The size of the drains should be measured, but it is sufficient to estimate the length and angle of inclination.
- The type of drain will normally be a pipe or scupper.
- Bearing details are needed primarily to determine whether the bearings should be replaced. This applies mainly to older structures. Where the size of bearings is not easily described, a sketch may be required. Irregularities in bearing performance, such as excessive tilt, should be noted under remarks.
- The sketch given for recording the location of catch basins is suitable for most structures. A separate sketch will be required for unusual alignments or complex geometry.

4.6/ Photographs

Colour photographs are required and, if at all possible, general views of the structure should be in a single photograph. Sawn sample photographs should show the condition of the waterproofing membrane or the condition of the deck surface. A photograph is required of each joint. Where extensive deterioration is evident, only typical areas need be photographed, e.g., a photograph of each spalled area is not required. Accessories such as a flashgun and a telephoto lens may be required to take satisfactory photographs of some parts of the structure.

4.7/ Sequence of Operations

The first task is for the engineer to carry out a visual appraisal of the condition of the deck and the components. This will enable him to determine the scope of the survey, the approximate number of samples and any unusual features or deterioration which will require special attention. It should also be clear at this time whether a boat, ladder or bucket truck will be required for inspection of the deck soffit, if this has not been decided on a previous site visit.

The typical sequence of operations for conducting a detailed condition survey of a deck with an exposed concrete surface and a bituminous concrete surface is shown below. Some tasks can be performed simultaneously where crew size allows.

Cores should not be taken until half cell testing is complete so that the deck remains dry. If cores are to be taken in wheel tracks, they should be done early so that the concrete used to repair the core hole can set before the lane is opened to traffic.

In early spring or late fall when temperatures in the early morning are too low for potential measurements, the delamination survey and component inspection can be the first operation.

If possible, the results of the half cell test and the delamination survey should be used to establish the location for taking cores and sawn samples.

4.7.1/ Decks with Concrete Surface

The following sequence of operations applies to exposed concrete decks:

- set up traffic control;
- lay out grid;
- establish ground locations for half cell;
- carry out half cell survey;
- delamination survey (deck, curbs, sidewalks);
- cover survey;
- coring program;
- plot deck surface deterioration (spalls, delaminations, scaling);
- inspect soffit and plot deterioration;
- component inspection; and
- photographs.

4.7.2/ Decks with Bituminous Concrete Surface

The following sequence of operations applies to decks with bituminous concrete surfaces:

- set up traffic control;
- lay out grid;
- establish ground location for half cell (by removing one sawn sample);
- drill holes for half cell testing and measure asphalt depths;
- carry out half cell survey;
- coring program;
- sawn samples;
- delamination survey on curbs and sidewalks;
- plot deck surface deterioration;
- component inspection; and
- photographs.

5/ CORE TESTING

5.1/ Photographs and Description

All cores shall be transported from the site for examination and testing. Each core will be described and photographed, except those taken from curbs or approaches where required under Clauses A8 and A9 or B7 and B8 of the standard agreement. The photograph must be in colour and include no more than three cores. Photographs should be taken in a studio environment against a neutral background. The cores should be arranged to show significant deterioration, unusual features and, where possible, embedded reinforcement. Cores with significant deterioration should be photographed individually. Multiple views (using mirrors) are not acceptable because they are not clear. In some cases, wetting the cores may improve the contrast and emphasize defects such as cracks and voids. It is good practice not to proceed with physical testing of the cores until the photographs have been printed and the quality is acceptable.

A sketch is required to show the overall dimensions of each core, the location of reinforcement and significant defects. The sketch should illustrate the same view of the core as the photograph.

In most cases, the above description of each core will be sufficient. However, where there is evidence of reaction rims, deleterious aggregates, extensive cracking or other types of physical distress, this should be noted in the description so that the Ministry can consider the need for a petrographic examination on some of the cores.

5.2/ Physical Testing

The intent of the physical testing programme is to obtain an assessment of the quality and durability of the concrete. This is done by testing cores for strength, chloride content, and, in some cases, air content. The number of cores tested varies with the deck size and the degree of deterioration. Specific instructions are given in Table 1 of Appendix A. These requirements have been developed to produce sufficient information for the least cost. All testing must be done in laboratories approved by MTC. A list of laboratories approved for testing cores can be obtained from the MTC Engineering Materials Office. For most decks, only a small proportion of the cores taken will be tested.

5.2.1/ Compressive Strength

The number of specimens to be tested increases as the degree of deck deterioration increases, but should not exceed six. The cores should be selected to represent the range of compressive strength of the deck concrete. Where the concrete is of a uniform, good quality, only one core need be tested.

All the cores must satisfy the requirement for $L/D \geq 1.0$. They should preferably be free from steel, though this will not always be possible. The cores must be conditioned in water for 48 hours in accordance with the requirements of CAN3-A23.2-14C. Results should be reported after correcting to an equivalent L/D ratio of 2.0 using the factors given in Table 1 of CAN3-A23.2-14C.

5.2.2/ Chloride Content

The method of sample preparation and testing is described in the document "Method of Testing for Water Soluble, Chloride Ion in Concrete" available from the Engineering Materials Office of the Ministry. The chloride content is measured on samples taken from alternate 10 mm thick slices to a depth of 90 mm except that, where there is evidence of significant deterioration (especially corrosion-induced distress) on the soffit of thin slab decks, the chloride content of alternate slices of a full-depth core should be measured. One core for chloride determination should be from an area near the curb since the chloride content is frequently highest in concrete near the curb.

The chloride content of the concrete will usually be highest adjacent to an external surface. Where the test results produce an unexpected profile through the thickness of the concrete, a duplicate determination should be made to verify anomalous values. Where the anomaly persists, it may be necessary to test the adjacent slices to ensure the results are realistic.

5.2.3/ Air-Void System

A single air-void determination is to be made for all structures built in 1958 and later. It can be assumed that the concrete in bridges built in Ontario prior to 1958 is non-air entrained.

The test method to be used is ASTM C457. Either the Linear Traverse or the Modified Point Count Method may be used. The values of air content, specific surface and spacing factor are to be reported. Paste content may be determined by measurement (Modified Point Count Method) or from the original mix proportions. Where the paste content is not known it is to be assumed to be 27%, but this assumption must be noted.

5.3/ Significance of Test Results

The compressive strength results should be compared with the strength specified on the original drawings. Wide variations in strength indicate local areas of deterioration. Values of less than 20 MPa represent poor quality concrete. It should be noted that concrete damaged by frost action, usually exhibited as horizontal cracks in the upper portion of the core, may register a high compressive strength but still be of a poor quality.

Concrete is normally considered to be properly air entrained if the air content exceeds 3%, the spacing factor is less than 0.20 mm and the specific surface exceeds 24 mm^2/mm^3.

The chloride threshold value necessary to depassivate embedded steel and permit corrosion (in the presence of oxygen and moisture) is usually taken to be 0.15% by mass of cement. For a typical cement factor of 300 kg/m^3 this corresponds to a chloride content of 0.02% by mass of concrete. Interpretation of chloride values is complicated by the fact that all the mix ingredients contain chloride ions, some of which are not available to initiate corrosion. The subject is further complicated in southern Ontario because the dolomitic limestone aggregates from the Niagara Escarpment contain relatively large (typically 0.12% by mass of aggregate) amounts of chloride ion which does not enter into the pore water solution. In order to determine whether sufficient chloride has entered the concrete to cause corrosion of the reinforcement, it is necessary to correct the test results for the "background" chloride content which is measured by the test method but does not contribute to corrosion. In the absence of a more precise method, this is usually done by subtracting the chloride content measured in the slices most remote from an external surface from the remaining values and then comparing the results with the threshold value of 0.02% by mass of concrete. Greater confidence can be placed in this approach if the chloride values in successive slices are sensibly the same, and the background value does not exceed about 0.07% by mass of concrete. An example of this procedure is given in Figure 2.

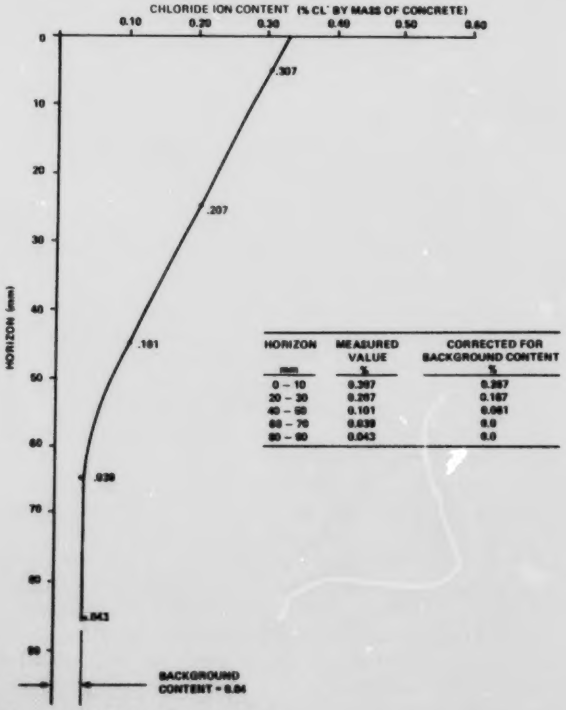
It should be noted that some of the limestone from the Niagara Escarpment will contribute approximately 0.05% Cl⁻ by mass of concrete to a mix. Conversely, if 2% calcium chloride dehydrate by weight of cement is used as an admixture, it contributes approximately 0.13% Cl⁻ by mass of concrete and a substantial proportion of this chloride ion is available to initiate corrosion.

It is important to note that actual measured values of chloride content are to be given in the report. However, the role of "background" chlorides must be considered in preparing the summary of significant findings.

5.4/ Retention of Samples

All cores, pieces of cores and unused pulverized material must be retained for six months after written acceptance of the Condition Survey report by the Ministry. Cores taken through curbs or sidewalks (as part of Clauses A9 or B8 of the standard agreement) shall be retained until notified by the Ministry.

Figure 2/ Establishing Background Value for Chloride Ion Content



HORIZON mm	MEASURED VALUE %	CORRECTED FOR BACKGROUND CONTENT %
0 – 10	0.307	0.267
20 – 30	0.207	0.167
40 – 50	0.101	0.061
60 – 70	0.039	0.0
80 – 90	0.043	0.0

6/ THE REPORT

6.1/ Introduction

The purpose of the report is to document the condition of the structure so that the results of the condition survey can be used to select the method of rehabilitation and prepare the contract documents. The prime requirement is that the report be concise and clear. Since the Ministry employs several consulting firms to carry out bridge deck condition surveys, it is necessary that a standard format be used for the report. This format is also to be followed for reports produced in-house. In order to facilitate the use of a standard format, forms have been developed for recording the data. This enables specific information to be located quickly and reduces the length of the text. Examples of reports written in the standard format on an exposed concrete bridge deck and on an asphalt-covered deck are given in Section 7.

Four copies of the report are required.

6.2/ Contents

The material in the report is presented in the following order:

- Table of Contents
- Structure Identification Sheet
- Summary of Significant Findings
- Survey Summary Sheet
- Component Inspection Forms
- Survey Equipment and Calibration Procedures
- Core Photographs and Sketches
- Core Logs
- Sawn Asphalt Sample Log (asphalt-covered decks only)
- Sawn Asphalt Sample Photographs (asphalt-covered decks only)
- Site Photographs
- Drawings

6.3/ Standard Forms

Data is recorded on the following standard forms:

- Structure Identification Sheet,
- Survey Summary Sheet[1],
- Component Inspection Form (2 pages),
- Survey Equipment and Calibration Procedures,
- Core Log[1], and
- Sawn Asphalt Sample Log.

The forms are contained in Appendix A. They are available in pad form from the Engineering Materials Office and the Regional Structural Sections of the Ministry. While it is permissible to adjust the spacing on the form to accommodate word processing equipment, the basic layout of each form is not to be changed.

6.3.1/ Guide to Completing the Standard Forms

The following guide has been prepared to clarify the information to be shown on the standard forms. Further clarification is provided by the examples contained in Section 7.

6.3.1.1/ Structure Identification Sheet

- AADT is available from Ministry Regional Offices.

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[1] The form is different for exposed concrete and asphalt decks.

- The Ministry District name and number can be obtained from the Regional Structural Sections.
- All members of the survey team are to be listed.
- The site number is the county site number. This will normally consist of a two digit county number followed by a bridge number of up to four digits. A slightly different system is used in unorganized townships. Twin structures and some structures in interchanges may also include a letter after the digits.

6.3.1.2/ Survey Summary Sheet

- The length and width of the deck are to be reported to the nearest 0.01 m.
- Where the deck geometry is complex, the deck area is to be taken from the design drawings.
- Crack lengths are measured on the drawings using a measuring wheel.
- Areas of scaling, spalling and delamination and increments of concrete cover and corrosion activity are measured on the drawings using a planimeter.
- In recording underside deterioration the crack lengths which are leached and/or stained are tabulated separately. For example the length of transverse cracks does not include the length of transverse cracks which are leached and/or stained.

6.3.1.3/ Component Inspection Form

- The form is designed for structures of up to three spans. Use additional forms for bridges having more than three spans.
- Additional information is contained in Section 4.5.

6.3.1.4/ Core and Sawn Sample Logs

- The location is normally given with respect to the grid lines.

6.4/ Text

The intent of the text is to summarize and explain significant deterioration or unusual findings. In this respect it can be compared to an executive summary. It is not necessary to describe test methods or field procedures since these are specified in the agreement. The text should be a concise discussion of the salient features found in the condition survey and should explain any relationships or inconsistencies in the observations and test results.

6.5/ Photographs

Coloured photographs (90 mm x 125 mm) are required for:

- a general view of the deck surface;
- a side elevation of the structure;
- significant areas of deterioration on the upper and lower deck surfaces and other components of the structure;
- each deck joint;
- the deck surface within a sawn asphalt sample; and
- each core.

The requirements for the photographs are given in the agreement and further details are contained in Sections 4.6 and 5.1. A colour print is required in each copy of the report.

6.6/ Drawings

6.6.1/ Requirements for Both Types of Deck

The drawings are prepared by transcribing the data from the field grid sheets. The following requirements apply to both exposed concrete and asphalt-covered deck surfaces:

- the scale shall be 1:100;
- pencil drawings and freehand lettering are acceptable providing they are neat and clear;
- deck drains, cores, sawn samples (asphalt-covered decks only) are to be shown on all drawings;
- a key plan showing the location of the structure is to be shown on at least one drawing;
- sidewalks, curbs, medians and joints together with the centreline of piers are required on all drawings;
- grid lines are to be shown on all drawings. The grid will be 1.5 m on exposed concrete decks and 3 m on asphalt-covered decks; and
- a legend is required to identify clearly the types of deterioration and features shown.

6.6.2/ Exposed Concrete Decks

Four plans are required for exposed concrete decks to show:

- Spalls, patches, delamination, scaled areas and significant cracks on the top surface of the deck, curbs and sidewalks. Crack widths shall be noted by using the abbreviations W, M, N (see Section 2.2.1).
- Concrete cover measurements at grid points and the 20, 35 and 50 mm contour lines. Areas between contour lines shall be shaded.
- Potential measurements at grid points (and intermediate points where taken) and the -0.20, -0.35, -0.45 and -0.55 V contour lines. Areas between contour lines shall be shaded.
- Deterioration on the bottom surface of the deck slab. The locations of longitudinal beams and void drains shall be shown, where present.

Where there is very little deterioration on both the top and bottom deck surfaces, and the information can be shown clearly, the plan for deterioration on the bottom may be combined with the plan for top surface deterioration.

6.6.3/ Asphalt-Covered Decks

Three plans are required for asphalt-covered decks to show:

- Significant cracks in the bituminous surfacing, the thickness of the asphalt at grid points and spalled, scaled and delaminated areas on the top surface of the curbs and sidewalks.
- Deterioration on the bottom surface of the deck slab. The location of longitudinal beams and void drains shall be shown, where present.
- Potential measurements at grid points (and intermediate points where taken) and the -0.20, -0.35, -0.45 and -0.55 V contour lines. Areas between contour lines shall be shaded.

7/ SAMPLE REPORTS

7.1/ Exposed Concrete Surface

Sample Report: Detailed Bridge Deck Condition Survey
Third Avenue Overpass Highway 7;
Site Number 33-597

SAMPLE

Detailed Bridge Deck Condition Survey

Third Avenue Overpass Highway 7

Site Number 33–597

Agreement: 4213-3614-67
May 1983

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1/ STRUCTURE IDENTIFICATION SHEET

NAME: Third Avenue Overpass, E.B.L. only.

SITE NO.: 33-597

HIGHWAY 7

AADT 5000

MTC REGION Southwest

MTC DISTRICT 3, Stratford

TYPE OF STRUCTURE Three-span 610 mm thick prestressed post-tensioned concrete slab with round voids.

YEAR BUILT 1965

DECK RIDING SURFACE Concrete

DATE OF SURVEY May 3 and 4, 1983

SURVEY TEAM R.B. Hornick, P.Eng.
Z. Wiszniowski, C.E.T.
S. Ramdewar, C.E.T.
J. M. Lau
M. Kavanagh

R. B. Hornick P. Eng.

2/ SUMMARY OF SIGNIFICANT FINDINGS

2.1/ Deck Surface

The concrete in the deck slab is of a good quality, high compressive strength (in excess of 40 MPa) and properly air-entrained. The deck surface is exposed concrete and exhibits numerous longitudinal cracks which coincide with the voids in the deck slab. Most of the cracks are narrow, though a few are wider and filled with sand and debris.

There are numerous isolated delaminations and spalls on the deck (totalling 4.9% of the deck area) and these are concentrated in the southwest corner of the deck. Most of the spalls have been patched with bituminous material which is now being broken out.

The average concrete cover to the reinforcement is good (46 mm), but it is as little as 15 mm in localized areas. The areas of least cover are:
- over the west pier
- on the south side of the structure directly over Third Avenue
- in the south east corner of the deck.

Only 3.6% of the deck area indicated active corrosion. This is less than would be expected given the amount of delamination and spalling in the deck slab.

Substantial differences were recorded in the chloride content in the 20 to 30 mm sections of the two cores tested. However, the results indicate the chloride content is at or above the threshold value for corrosion in the top 30 mm of concrete. After allowing for background chloride levels, the chloride content more than 40 mm below the surface is less than the threshold value for corrosion. Given the relatively high cover over much of the deck, the chloride values partly explain the low corrosion potentials recorded.

There was a thin concrete topping on the southwest corner of the deck. This appears to have been placed at the time of the original construction to correct surface defects. The topping is exhibiting localized spalling and, though unsightly, this has no effect on the adequacy of the structure and only a slight effect upon the riding quality of the deck.

2.2/ Deck Underside

The deck soffit exhibits numerous longitudinal cracks. Most of these are wet and stained brown by water leaking through the paper void forms. There are several areas of spalling at both ends of the deck within 1 m of each abutment. Most of the spalled concrete is sitting on the bearing seats. These spalls are the result of surface run off leaking through the joints and causing corrosion of the bottom reinforcement.

2.3/ Components

The approach slabs consist of concrete which is 250 mm thick and in good condition. The parapet wall has numerous vertical hairline cracks, light scaling and rust staining. The southwest end post shows corrosion spalling.

The joints consist of a compression seal at each abutment set directly in the concrete. Both joints are leaking badly.

The faces of the abutments are wet and have rust and efflorescence stains. The bearing seats are in good condition, but the haunches above some of the bearings exhibit corrosion spalling. The ballast walls are wet and have vertical hairline cracks but otherwise appear to be sound. The bearings at both abutments are in good condition. The pier bearings are inaccessible.

3/ SURVEY SUMMARY SHEET

SITE NO. 33 - 597

SURVEY SUMMARY SHEET
FOR EXPOSED CONCRETE DECKS

1. DIMENSIONS OF DECK

Length between abutment joints	46.5	m	*(Parallel ℄ Highway)*
Width between curbs or sidewalks	22.2	m	[✓ N] E Abutment
	25.7	m	[✓ S] W
Deck area (riding surface only)	1095.7	m²	
Curb area (including median curb)	63.7	m²	
Sidewalk area	*N/A*	m²	

2. CRACKING (Deck only)

	Narrow	Medium	Wide	
Transverse				m
Longitudinal	250		70	m
Diagonal				m
Random				m

REMARKS

3. SCALING

	Deck	Sidewalks	Curbs	
Light	202.5			m²
Medium				m²
Heavy				m²
Severe				m²

4. DELAMINATION AND SPALLING

	Deck	Sidewalks	Curbs	
Patches	5.5			m²
Open Spalls	0.5			m²
Delamination	47.5			m²

Most spalls have been patched with asphalt. No exposed reinforcing steel.
SEE FIGURE 13

5. CONCRETE COVER

	Min.	Max.	Ave.	
Cover	15	90	46	mm

0 – 20 mm	2	m²
20 – 35 mm	170	m²
35 – 50 mm	535	m²
Over 50 mm	320	m²

6. CORROSION ACTIVITY

	Min.	Max	Ave.	
Half Cell Potential	0.01	0.61	0.21	VCSE

0 to -.20 V	390	m²
-.21 to -.35 V	595	m²
-.36 to -.45 V	38	m²
-.46 to -.55 V	2	m²
less than -.55 V		m²

7. UNDERSIDE DETERIORATION

		Leached and/or Stained	
Cracking – Transverse	—	—	m
Longitudinal	50	120	m
Other	—	—	m
Wet Spots	50		m²
Spalls	12		m²
Honeycombing	—		m²
Other *(Scaling)*	21		m²

Longitudinal cracks wet and stained brown (from paper void liner).
SEE FIGURE 17

Areas of spalling are confined to within 1 m of the end of the deck at both abutments. Several pieces of spalled concrete were present on the bearing seat.
SEE FIGURES 19, 20

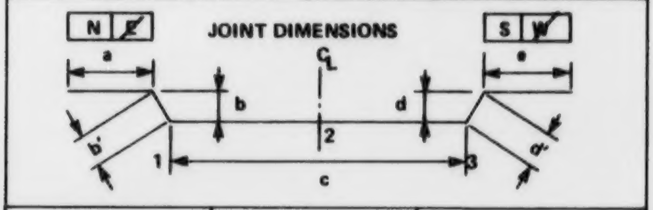
4/ COMPONENT INSPECTION FORMS

COMPONENT INSPECTION FORM **SITE NO.** 33 - 597

Page 1 of 2

1 JOINTS

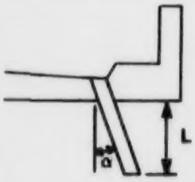
		ABUTMENTS				INTERMEDIATE		REMARKS
DIMENSION		N	E	S	W			
a	m	0.37		0.40				
b	mm	180		195				
b'	mm	195		200				
c	m	23.12		26.2				
d	mm	145		145				
d'	mm	155		155				
e	m	0.66		0.60				
GAP DIMENSION								
1	mm	75		65				
2	mm	65		70				
3	mm	65		70				Sand and debris in expansion joints.
EXP.		X		X				
FIXED								
TYPE		Compression Seals						
LEAKING		Yes		Yes				SEE FIGURE 18
ANGLE SIZE	mm							No steel angles



TEMPERATURE °C	DECK	AMBIENT
	14	16

2 DRAINS

NUMBER	TYPE	LENGTH	α
None			



3 BEARINGS

	ABUTMENTS				PIERS	
	N	E	S	W		
NUMBER	6		6			
TYPE	Elastomeric					
SIZE	457 x 254		457 x 254			
CONDITION *	G		G			
BEARING SEAT *	G		G			

Abutment bearing seats in immediate vicinity of the bearings are sound. Accumulations of bedding grout around each bearing. Some haunches above the bearings are exhibiting corrosion spalling because of the leaking expansion joints.
SEE FIGURES 19, 20

Pier bearings inaccessible.

*** Condition – G = Good, F = Fair, P = Poor**

COMPONENT INSPECTION FORM

Page 2 of 2

SITE NO. 33 - 597

4 SUBSTRUCTURES

	LOCATION	CONDITION *
ABUTMENTS	E, W	F
BALLAST WALLS	E, W	F
PIERS	E, W	G
SLOPE PAVING	E, W	G

REMARKS

Heavily water marked, rust stained- fine vertical cracks.

Vertical cracks, rust staining but no scaling or spalling evident.

5 HANDRAILS AND PARAPETS

		NUMBER	CONDITION*
PARAPET WALLS WITH ~~1~~/2 RAILS		1	G
BARRIER WALLS			
POSTS	CONCRETE *end posts*	2	G
	STEEL	20	G
PANELS	CONCRETE		
	STEEL	19	G
OTHER			

Parapet walls have hairline vertical cracks, rust staining and some light scaling along inside face.

Concrete endposts have vertical hairline cracks with spall at SE post.

SEE FIGURE 14

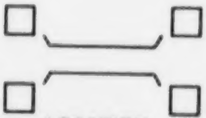
One steel rail at SE corner damaged.

6 APPROACHES

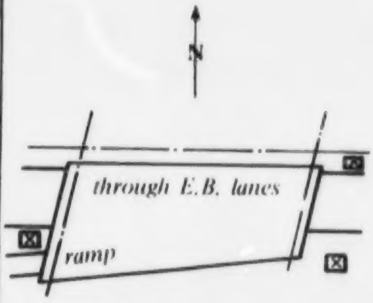
			EXPOSED CONCRETE	ASPHALT	CONDITION*
APPROACH SLABS	YES	X	X		G
	NO				
APPROACH ROAD SURFACE				X	G

CURB AND GUTTER	YES	X	CONDITION*
	NO		F

			NUMBER
CATCH BASINS	YES	X	3
	NO		



LOCATION (SHOW NORTH)



Catch Basin Locations

7 BEAMS

TYPE	None
NUMBER	
CONDITION*	

* Condition – G = Good, F = Fair, P = Poor

5/ SURVEY EQUIPMENT AND CALIBRATION PROCEDURES

SITE NO. *33 - 597*

SURVEY EQUIPMENT
AND CALIBRATION PROCEDURES

SURVEY EQUIPMENT [1]

1. DELAMINATION
   weight of chain (kg/m) *2.2 kg/m with 50 mm links*
   other equipment

2. COVER
   pachometer(s) *James R. Meters (2) Model No. C - 4979 Serial Nos. 5221 and 5510*

3. CORROSION ACTIVITY
   half cell *Miller Model RE - 3*
   voltmeter *Beckman Digital Model 3020*
   length and gauge of lead wire *80 m, 18 Gauge*

CALIBRATION AND CHECKING

	Deck	Ambient
Temperature at start of test	*13*	*15*
Temperature at end of test	*21*	*18*

4. COVER
   a) Battery check
   Reading at start of test *9.4* *Readings over 8.7 are ok*
   Reading at end of test *9.3*

   b) Location of cover check *Core holes C2 and C5:*
   Actual depth and size of bar *C2/55 mm depth—22 mm bar C5/50 mm depth--bar size not known*
   Reading before test *55,50*
   Reading during test [2] *55,50* *55,50*
   Reading end of test *55,50*

5. CORROSION ACTIVITY
   a) Battery check: *O.K.*
   b) Ground – location *Core holes C2 and C5*
   – method of connection *Self tapping screw*
   – resistance and location of check *C2 to anchor bolt in handrail, 3.6 Ω C5 to hole drilled in median curb, 3.6 Ω*
   – cover at ground locations *55 mm at C2, 50 at C5*

   c) Grid Point Readings

LOCATION	INITIAL READING Volts, CSE		CHECK [3]	
G.L. 13.5 Stn. 6	*0.19*	*0.18*	*0.19*	*0.19*
G.L. 13.5 Stn. 13.5	*0.36*	*0.37*	*0.35*	*0.36*
G.L. 13.5 Stn. 16.5	*0.12*	*0.12*	*0.11*	*0.12*
G.L. 13.5 Stn. 24	*0.40*	*0.39*	*0.41*	*0.40*
G.L. 13.5 Stn. 30	*0.38*	*0.38*	*0.39*	*0.37*
	(1)	*(3)*	*(2)*	*(4)*

(1) Initial reading Ground C2
(2) Final reading Ground C2
(3) Intial reading Ground change to C5
(4) Final reading Ground C5

---

[1] Give Manufacturer and Model No. where applicable

[2] At least one reading per hour of test

[3] Check at least five readings at beginning and end of test and at each change of ground.

6/ CORE PHOTOGRAPHS AND SKETCHES

Figure 5/ Site 33-597, Core 3-C-1

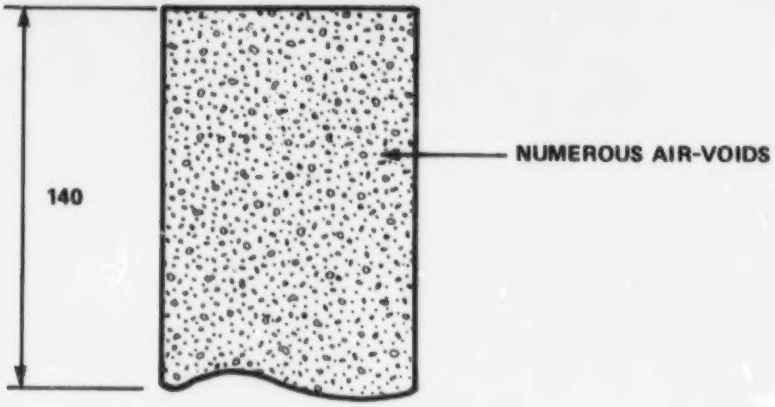

140
NUMEROUS AIR-VOIDS

Figure 6/ Site 33-597, Core 3-C-2

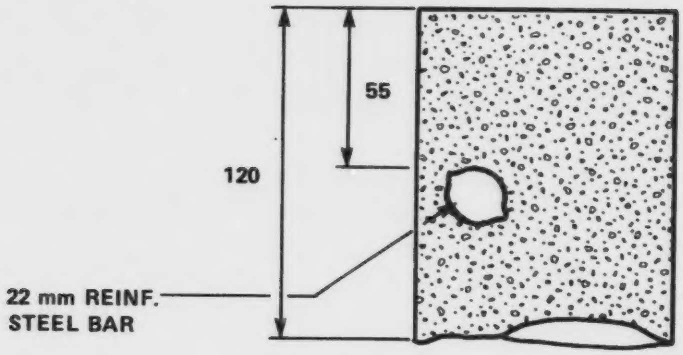

55
120
22 mm REINF.
STEEL BAR

Figure 7/ Site 33-597, Core 3-C-3

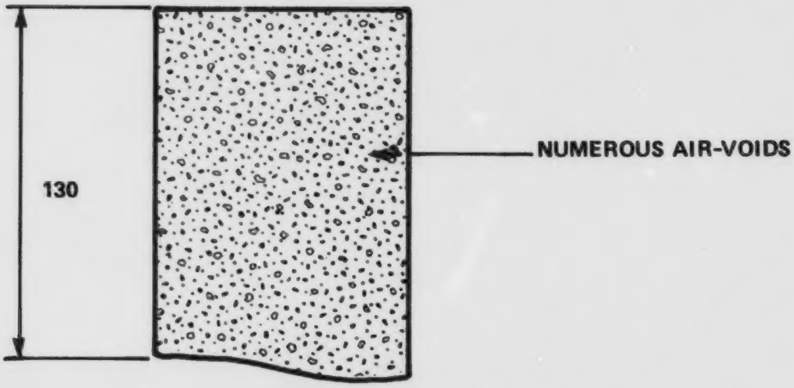

130
NUMEROUS AIR-VOIDS

Figure 8/ Site 33-597, Core 3-C-4

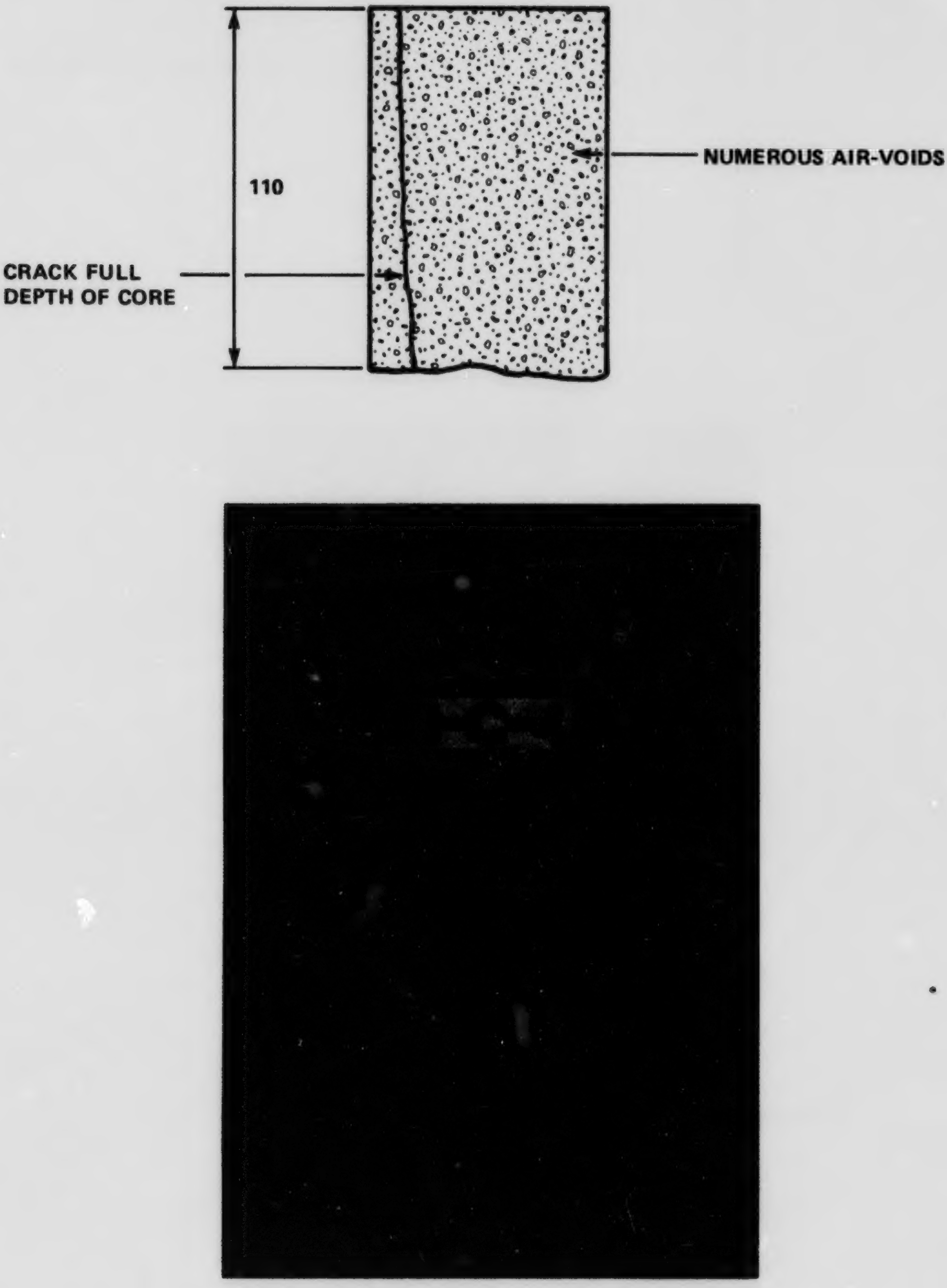
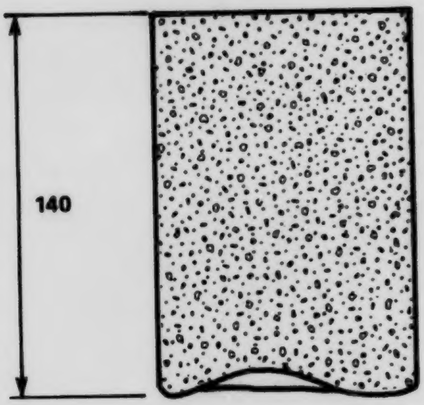

NUMEROUS AIR-VOIDS
110
CRACK FULL DEPTH OF CORE

Figure 9/ Site 33-597, Core 3-C-5



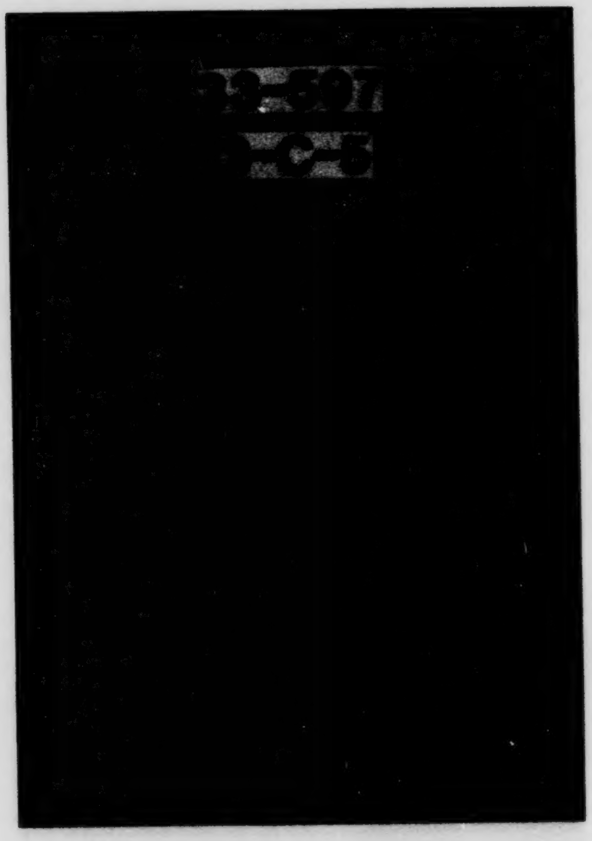
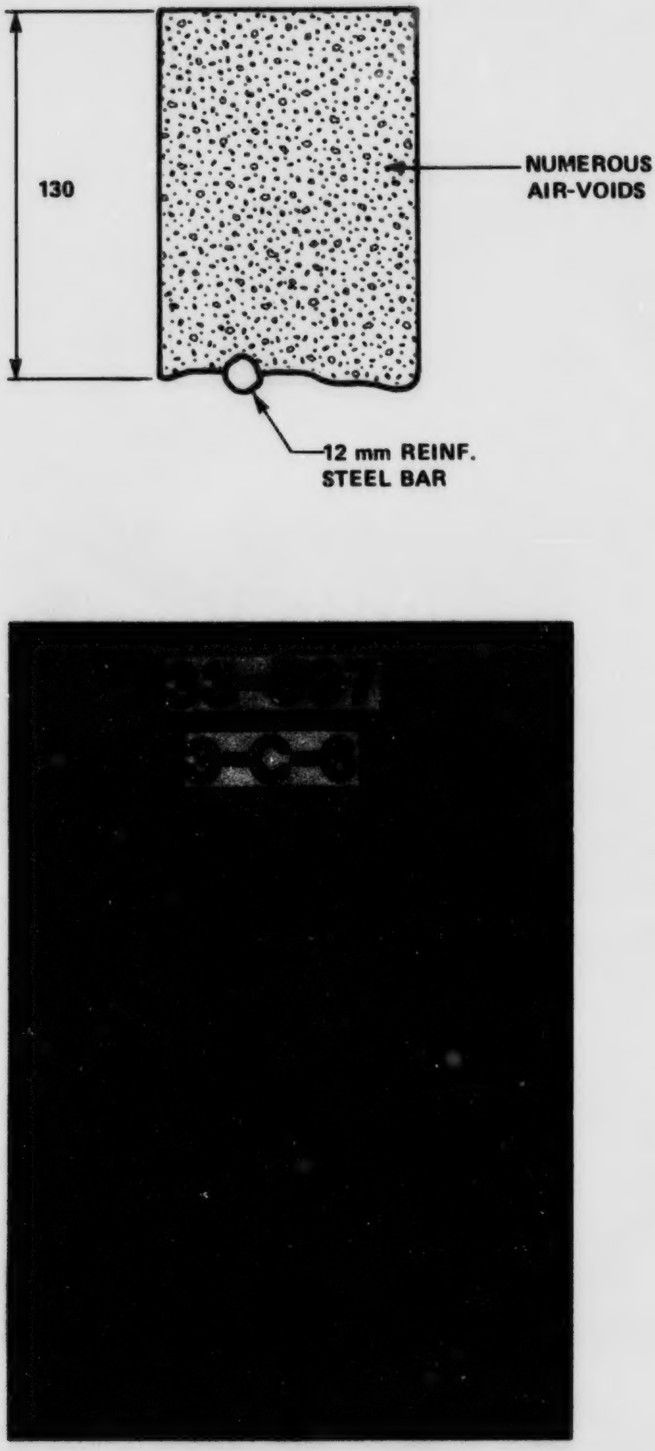
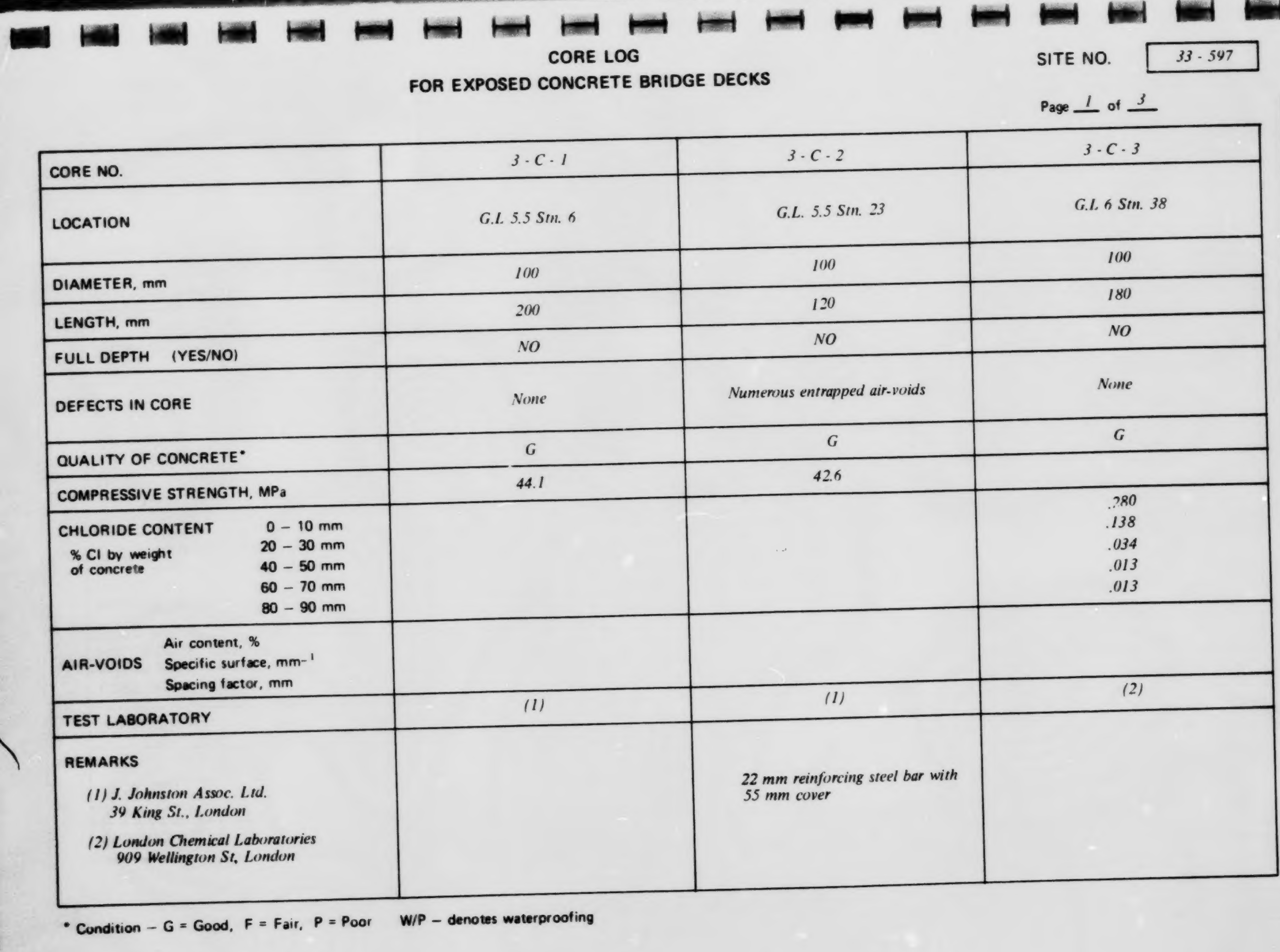


Figure 10/ Site 33-597, Core 3-C-6


130
NUMEROUS AIR-VOIDS
12 mm REINF. STEEL BAR

7/ CORE LOGS



CORE LOG
FOR EXPOSED CONCRETE BRIDGE DECKS

SITE NO. 33 - 597

Page 1 of 3

		3 - C - 1	3 - C - 2	3 - C - 3
CORE NO.		3 - C - 1	3 - C - 2	3 - C - 3
LOCATION		G.L 5.5 Stn. 6	G.L. 5.5 Stn. 23	G.L 6 Stn. 38
DIAMETER, mm		100	100	100
LENGTH, mm		200	120	180
FULL DEPTH (YES/NO)		NO	NO	NO
DEFECTS IN CORE		None	Numerous entrapped air-voids	None
QUALITY OF CONCRETE*		G	G	G
COMPRESSIVE STRENGTH, MPa		44.1	42.6	
CHLORIDE CONTENT % Cl by weight of concrete	0 – 10 mm			.280
	20 – 30 mm			.138
	40 – 50 mm			.034
	60 – 70 mm			.013
	80 – 90 mm			.013
AIR-VOIDS	Air content, %			
	Specific surface, mm^{-1}			
	Spacing factor, mm			
TEST LABORATORY		(1)	(1)	(2)
REMARKS *(1) J. Johnston Assoc. Ltd. 39 King St., London* *(2) London Chemical Laboratories 909 Wellington St, London*			22 mm reinforcing steel bar with 55 mm cover	

* Condition – G = Good, F = Fair, P = Poor W/P – denotes waterproofing

CORE LOG
FOR EXPOSED CONCRETE BRIDGE DECKS

SITE NO. 33 - 597

Page 2 of 3

CORE NO.	*3 - C - 4*	*3 - C - 5*	*3 - C - 6*
LOCATION	*G.L. 10 Stn. 17.5*	*G.L. 14 Stn. 25*	*G.L. 20.5 Stn. 43.5*
DIAMETER, mm	*100*	*100*	*100*
LENGTH, mm	*140*	*150*	*160*
FULL DEPTH (YES/NO)	*NO*	*NO*	*NO*
DEFECTS IN CORE	*Numerous entrapped air-voids. Narrow vertical crack full depth of core.*	*None*	*Numerous entrapped air-voids*
QUALITY OF CONCRETE*	G	G	G
COMPRESSIVE STRENGTH, MPa			
CHLORIDE CONTENT % Cl by weight of concrete 0 – 10 mm 20 – 30 mm 40 – 50 mm 60 – 70 mm 80 – 90 mm			 *.257* *.043* *.012* *.014* *.013*
AIR-VOIDS Air content, % Specific surface, mm^{-1} Spacing factor, mm		 *4.7* *26.3* *0.18*	
TEST LABORATORY		*(1)*	*(2)*
REMARKS *(1) J. Johnston Assoc. Ltd. 39 King St., London* *(2) London Chemical Laboratories 909 Wellington St., London*		*Edge of reinforcing steel bar exposed inside core hole. 50 mm cover.*	*12 mm reinforcing steel bar with 125 mm cover*

* Condition – G = Good, F = Fair, P = Poor W/P – denotes waterproofing

CORE LOG
FOR EXPOSED CONCRETE BRIDGE DECKS

SITE NO. 33 - 597

Page 3 of 3

CORE NO.	*3 - C - 7*		
LOCATION	*Approach slab, 3 m from expansion joint at east abutment, G.L. 9*		
DIAMETER, mm	*100*		
LENGTH, mm	*250*		
FULL DEPTH (YES/NO)	*Yes*		
DEFECTS IN CORE	*None*		
QUALITY OF CONCRETE*	*G*		
COMPRESSIVE STRENGTH, MPa			
CHLORIDE CONTENT % Cl by weight of concrete 0 – 10 mm 20 – 30 mm 40 – 50 mm 60 – 70 mm 80 – 90 mm			
AIR-VOIDS Air content, % Specific surface, mm^{-1} Spacing factor, mm			
TEST LABORATORY			
REMARKS			

* Condition – G = Good, F = Fair, P = Poor W/P – denotes waterproofing

8/ SITE PHOTOGRAPHS

THIRD AVENUE OVERPASS E.B. LANES ONLY **SITE 33-597, HWY. 7**

**Figure 11/
General View of Deck
Surface Looking East**

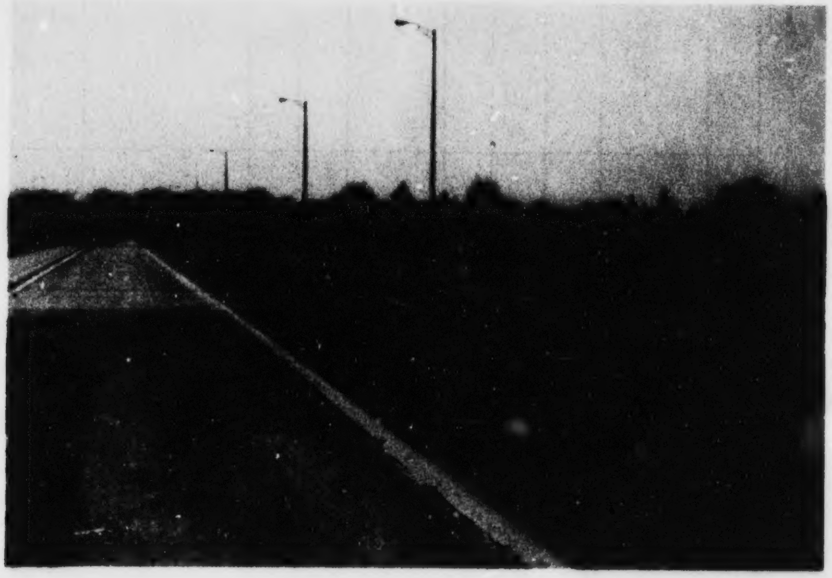


**Figure 12/
South Elevation**

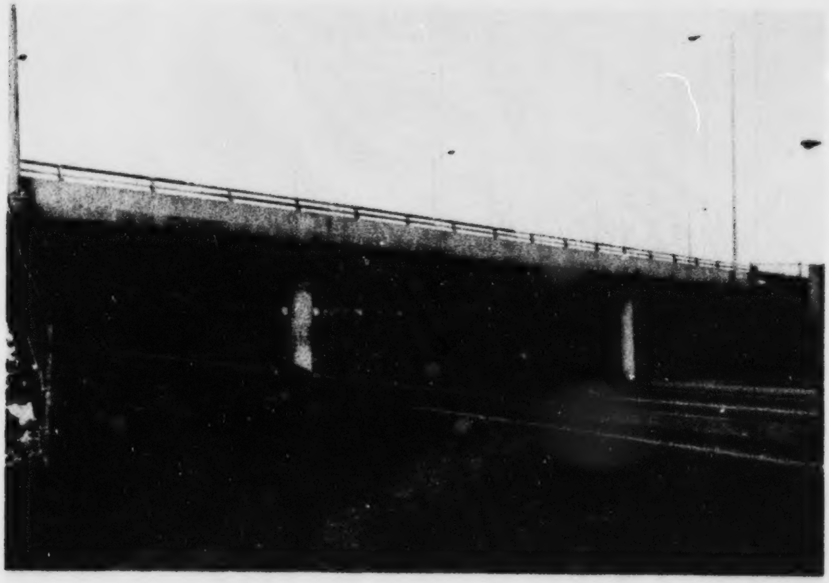


Figure 13/ Patched Spalled Areas at S.W. Corner of Deck

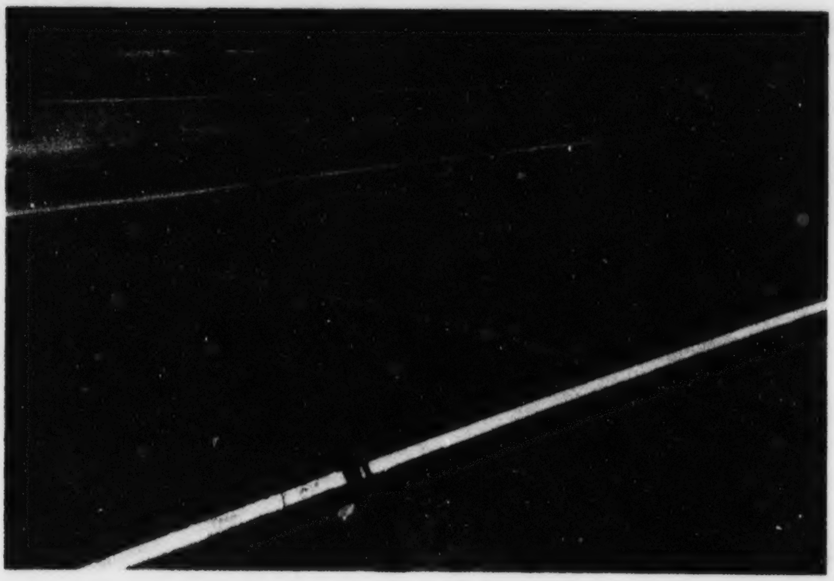


Figure 14/ Spall on Face of S.W. Parapet Wall End Post

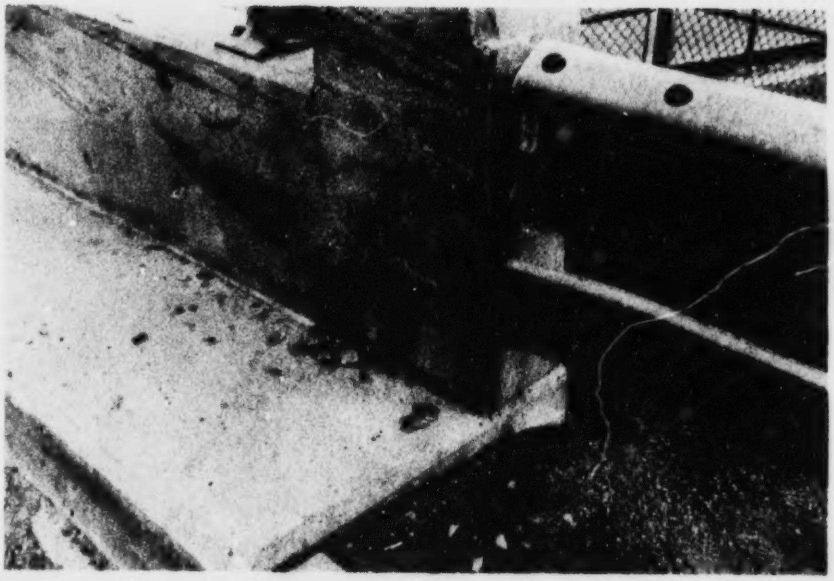


Figure 15/ West Abutment Joint

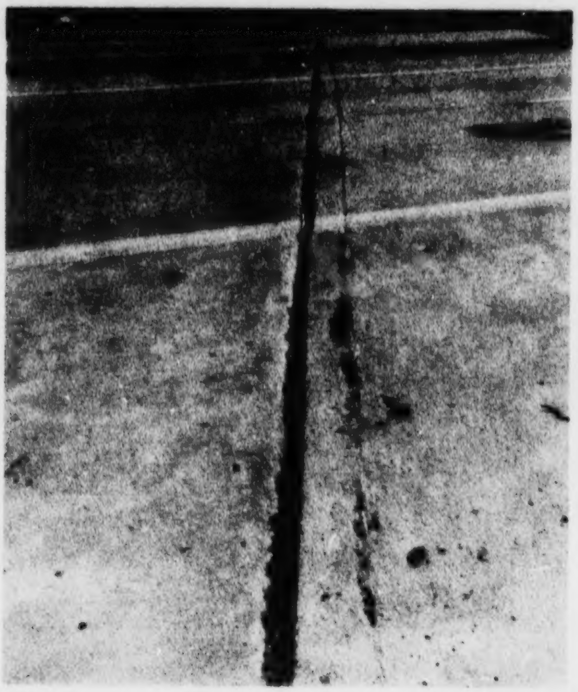


Figure 16/ East Abutment Joint

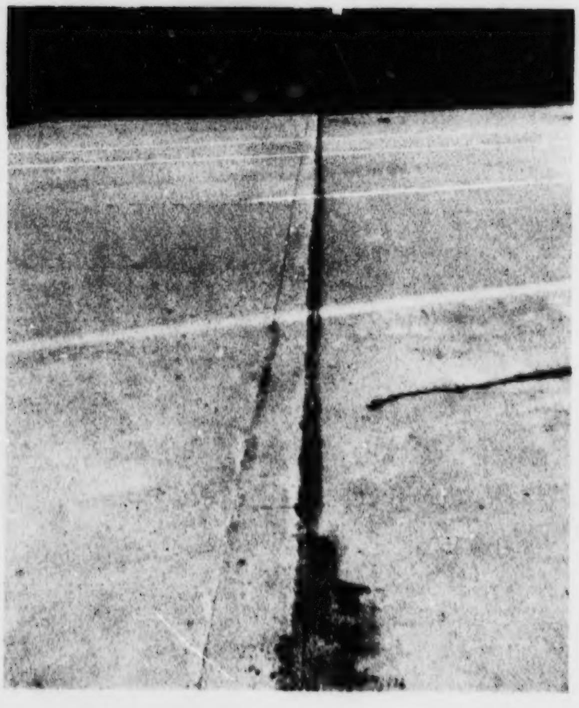
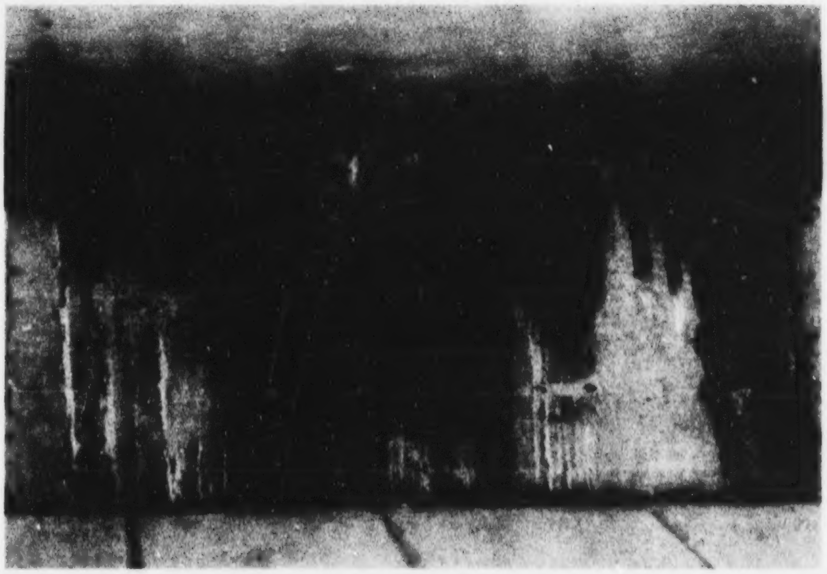


Figure 17/ Longitudinal Cracking on Soffit
Efflorescence and Staining

Figure 18/
East Abutment Face
Wet Due to Leakage
Through Joint Typical
for West Abutment.



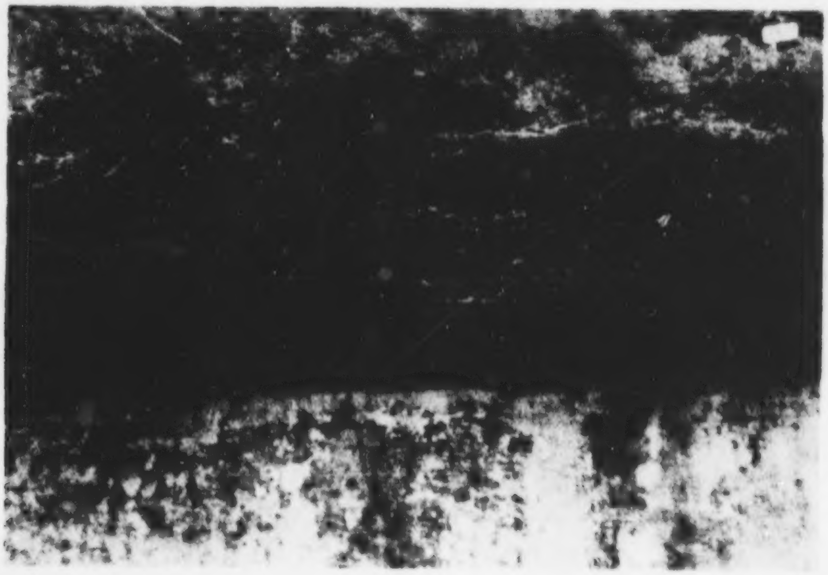


Figure 19/
Spalling on Soffit
Over Abutment
Bearing Seat

Figure 20/
Spalling on Soffit
Over Abutment
Bearing Seat

Figure 21/
Longitudinal Cracking on Deck Surface

9/ SITE DRAWINGS

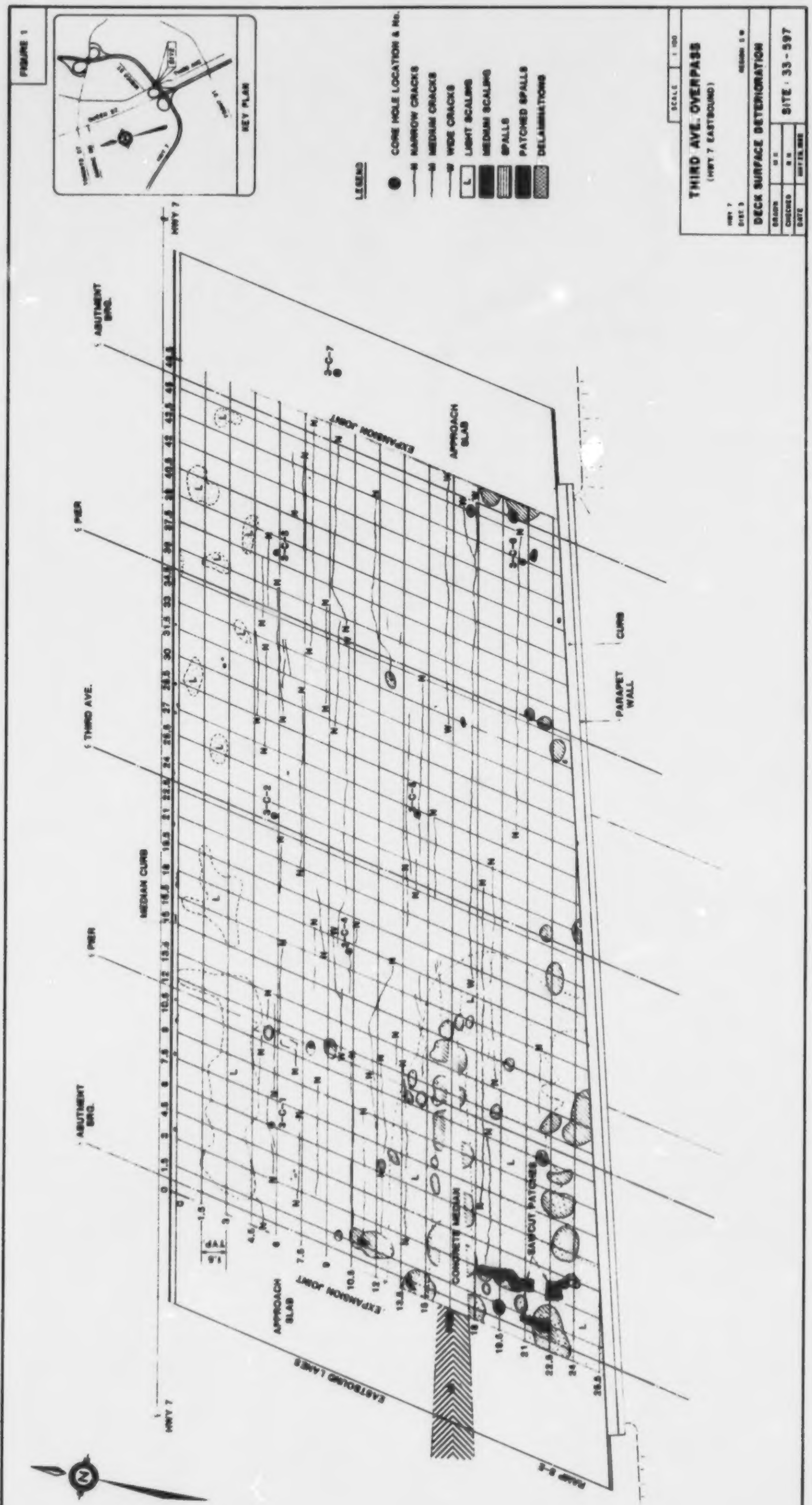


FIGURE 1
KEY PLAN
LEGEND
CORE HOLE LOCATION & No.
NARROW CRACKS
MEDIUM CRACKS
WIDE CRACKS
LIGHT SCALING
MEDIUM SCALING
SPALLS
PATCHED SPALLS
DELAMINATIONS
SCALE 1:100
THIRD AVE. OVERPASS
(HWY 7 EASTBOUND)
HWY 7
DIST 3
DECK SURFACE DETERIORATION
DRAWN
CHECKED
DATE
SITE : 33-597
ABUTMENT BRG.
PIER
THIRD AVE.
MEDIAN CURB
HWY 7
APPROACH SLAB
EXPANSION JOINT
CURB
PARAPET WALL
SAWCUT PATCHES
CONCRETE MEDIAN
EASTBOUND LANES
RAMP E-S
3-C-1
3-C-2
3-C-4
3-C-5
3-C-6
3-C-7

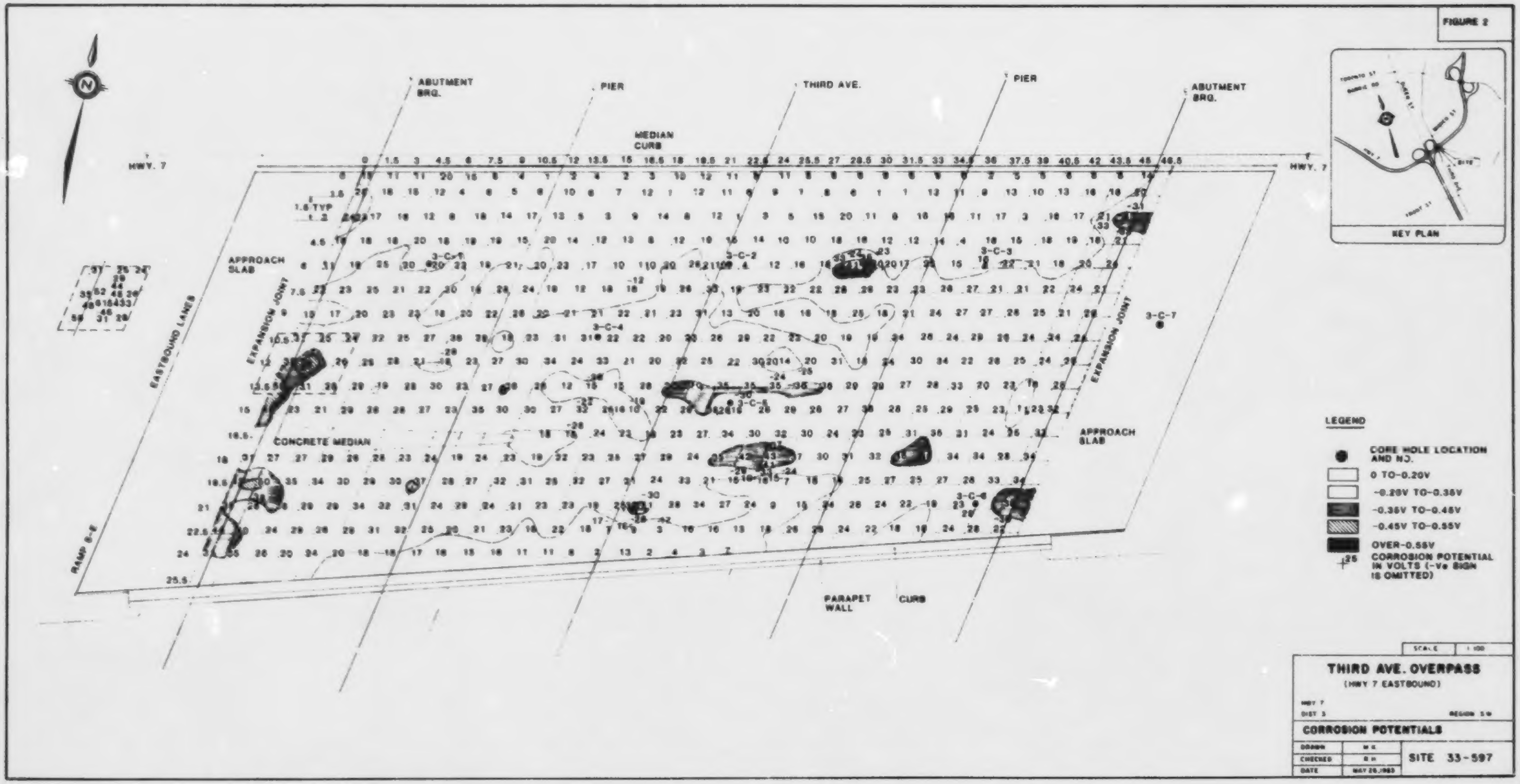


FIGURE 2
KEY PLAN
ABUTMENT BRG.
PIER
THIRD AVE.
PIER
ABUTMENT BRG.
MEDIAN CURB
HWY. 7
HWY. 7
0 1.5 3 4.5 6 7.5 9 10.5 12 13.5 15 16.5 18 19.5 21 22.5 24 25.5 27 28.5 30 31.5 33 34.5 36 37.5 39 40.5 42 43.5 45 46.5
1.5 TYP
APPROACH SLAB
EXPANSION JOINT
3-C-1
3-C-2
3-C-3
3-C-4
3-C-5
3-C-6
3-C-7
CONCRETE MEDIAN
EXPANSION JOINT
APPROACH SLAB
EASTBOUND LANES
RAMP 8-E
PARAPET WALL
CURB
LEGEND
CORE HOLE LOCATION AND NO.
0 TO-0.20V
-0.20V TO-0.35V
-0.35V TO-0.45V
-0.45V TO-0.55V
OVER-0.55V
25 CORROSION POTENTIAL IN VOLTS (-Ve SIGN IS OMITTED)
SCALE 1:100
THIRD AVE. OVERPASS
(HWY 7 EASTBOUND)
HWY 7
DIST 3
REGION SW
CORROSION POTENTIALS
DRAWN M K
CHECKED R H
DATE MAY 26,1983
SITE 33-597

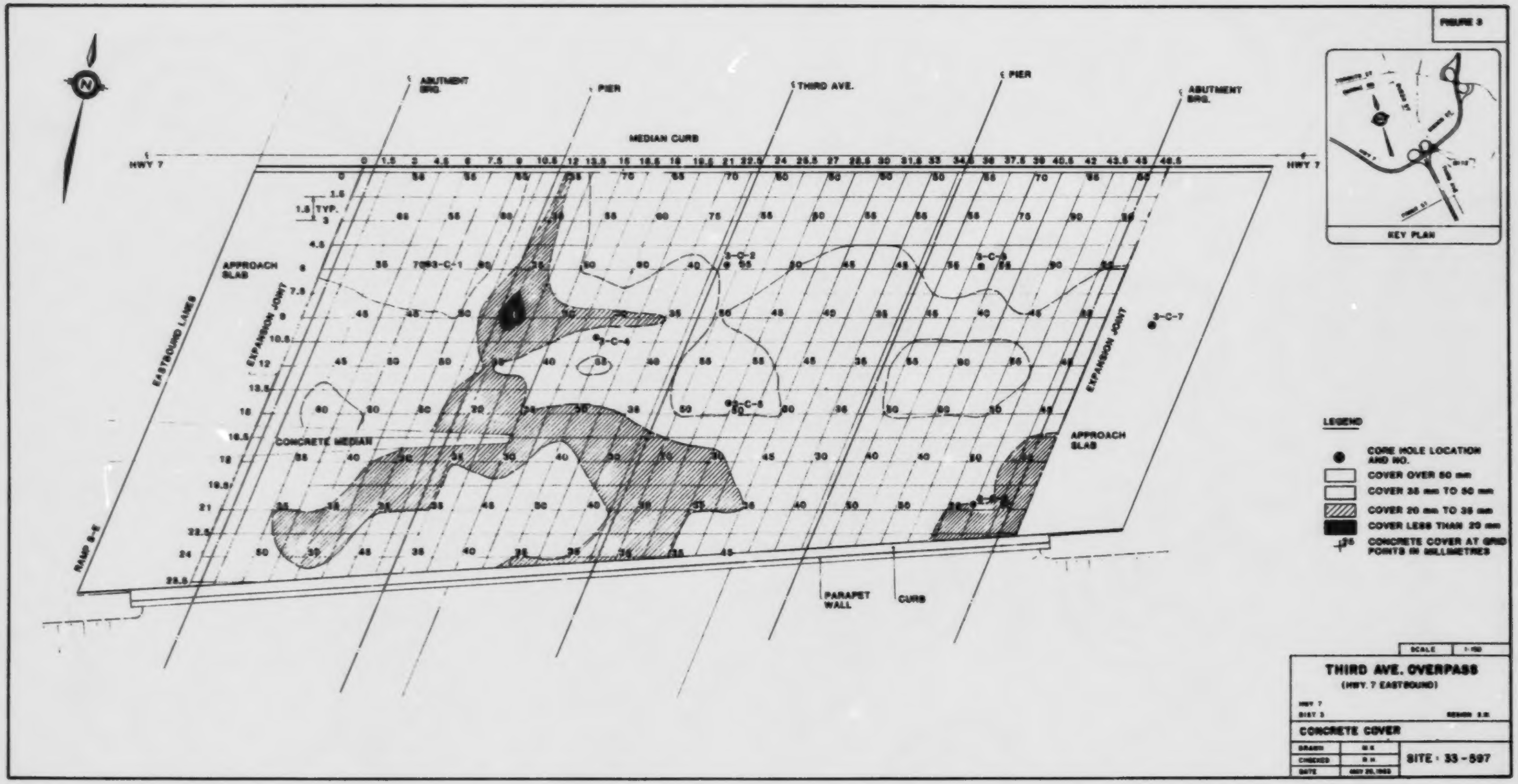
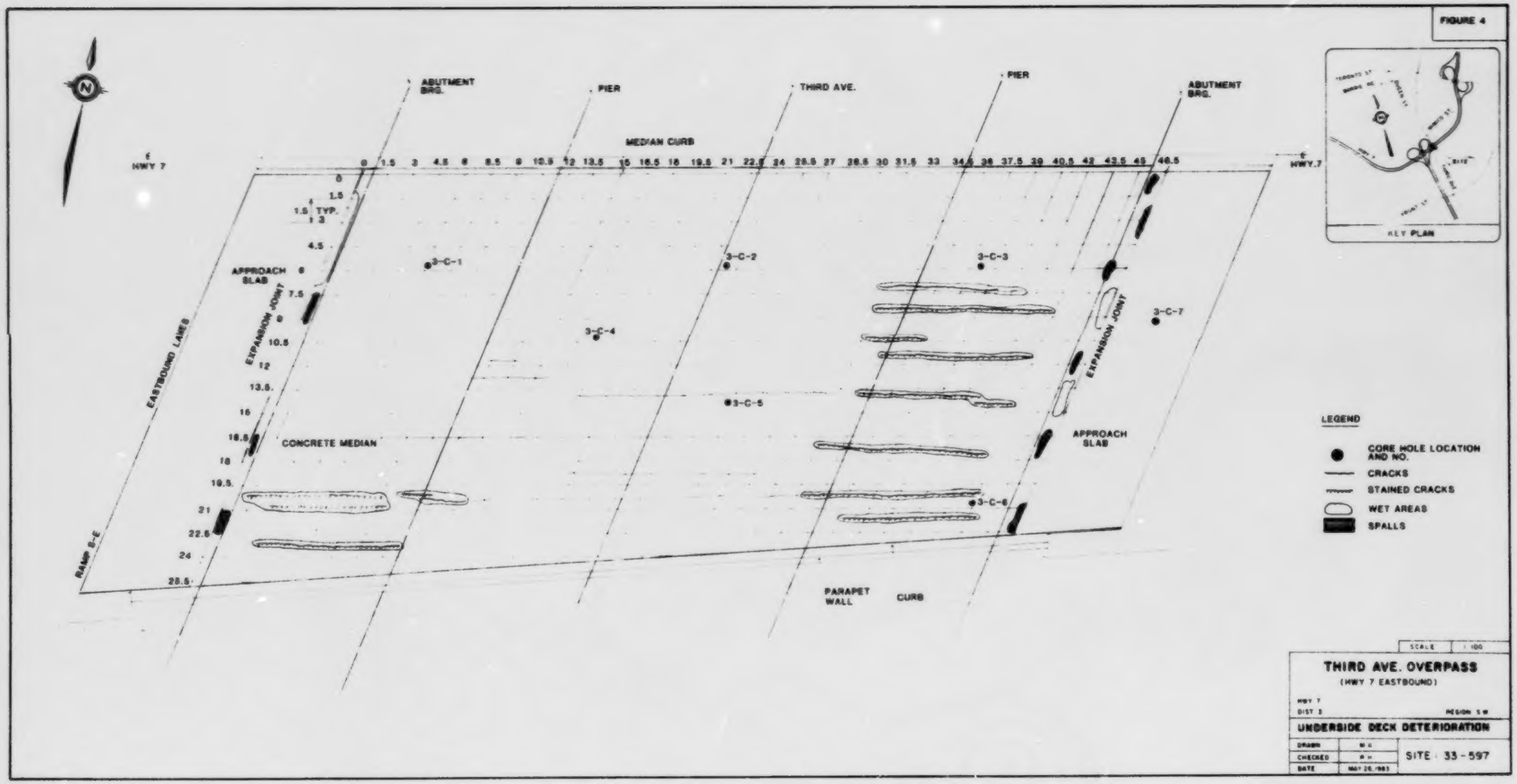


FIGURE 3
KEY PLAN
HWY 7
MEDIAN CURB
℄ ABUTMENT BRG.
℄ PIER
℄ THIRD AVE.
℄ PIER
℄ ABUTMENT BRG.
APPROACH SLAB
EXPANSION JOINT
EASTBOUND LANES
RAMP S-E
CONCRETE MEDIAN
1.5 TYP.
7063-C-1
3-C-2
3-C-3
3-C-4
3-C-5
3-C-6
3-C-7
PARAPET WALL
CURB
LEGEND
CORE HOLE LOCATION AND NO.
COVER OVER 50 mm
COVER 35 mm TO 50 mm
COVER 20 mm TO 35 mm
COVER LESS THAN 20 mm
CONCRETE COVER AT GRID POINTS IN MILLIMETRES
SCALE
THIRD AVE. OVERPASS
(HWY. 7 EASTBOUND)
HWY 7
DIST 3
CONCRETE COVER
DRAWN
CHECKED
DATE
SITE : 33-597

FIGURE 4


N
℄ HWY 7
ABUTMENT BRG.
PIER
THIRD AVE.
PIER
ABUTMENT BRG.
MEDIAN CURB
℄ HWY.7
0 1.5 3 4.5 6 7.5 9 10.5 12 13.5 15 16.5 18 19.5 21 22.5 24 25.5 27 28.5 30 31.5 33 34.5 36 37.5 39 40.5 42 43.5 45 46.5
0
1.5
1.5 TYP.
3
4.5
6
7.5
9
10.5
12
13.5
15
16.5
18
19.5
21
22.5
24
25.5
APPROACH SLAB
EXPANSION JOINT
EASTBOUND LANES
RAMP S-E
CONCRETE MEDIAN
3-C-1
3-C-2
3-C-3
3-C-4
3-C-5
3-C-6
3-C-7
EXPANSION JOINT
APPROACH SLAB
PARAPET WALL
CURB
TORONTO ST
HWY 7
SITE
KEY PLAN
LEGEND
CORE HOLE LOCATION AND NO.
CRACKS
STAINED CRACKS
WET AREAS
SPALLS
SCALE 1:100
THIRD AVE. OVERPASS
(HWY 7 EASTBOUND)
HWY 7
DIST 3
REGION S.W.
UNDERSIDE DECK DETERIORATION
DRAWN
CHECKED
DATE
MAY 26, 1983
SITE : 33-597

7/ SAMPLE REPORTS
(Continued)

7.2/ Bituminous Concrete Surface

Sample Report: Detailed Bridge Deck Condition Survey
Esmeralda Township 7th Line Underpass,
Highway 401
Site Number 33-199

SAMPLE

Detailed Bridge Deck Condition Survey

Esmeralda Township 7th Line Underpass
Highway 401

Site Number 33–199

Agreement: 811-3976-2
October 1982

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7/ CORE LOGS 16

8/ SAWN ASPHALT SAMPLE LOG 20

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10/ SITE PHOTOGRAPHS (FIGURES 16-25) 22

11/ SITE DRAWINGS (FIGURES 1-3) .... Following 27

1/ STRUCTURE IDENTIFICATION SHEET

NAME: Esmeralda TWP 7th Line Underpass

SITE NO.: 33-199

HIGHWAY 401

AADT 1000

MTC REGION Southwest

MTC DISTRICT 3 Stratford

TYPE OF STRUCTURE Four-Span Continuous Reinforced Concrete 'T' Beam

YEAR BUILT 1959

DECK RIDING SURFACE Asphalt

DATE OF SURVEY September 15 and 16, 1982

SURVEY TEAM S. Scialdone, P. Eng.
P.R. Glover, C.E.T.
J. Godrijan
G. D'Angelo

S. Scialdone P. Eng.

2/ SUMMARY OF SIGNIFICANT FINDINGS

2.1/ Bituminous Surfacing and Waterproofing

The bituminous surfacing contains numerous longitudinal and transverse cracks, especially in the northerly two spans. There are also wide, transverse cracks in the surfacing at each end of the structure, immediately above the joint between the deck slab and the approach slab. Ponding of water was noted near the east curb, near Station 55.5.

The deck is not waterproofed, and the bond of the asphalt to the concrete is poor. The asphalt thickness varied between 65 to 95 mm, but the substantial majority of measurements were within the range of 75 ± 5 mm.

2.2/ Concrete Deck Slab

The concrete deck slab was in generally good condition. Light scaling was observed, particularly beneath the sawn sample taken adjacent to the curb. The compressive strength of the concrete was high (over 40 MPa). Although the air content was relatively high, the concrete is not properly air-entrained. Cover measurements in the sawn sample areas were in the range of 40 to 55 mm. All of the potential measurements were less negative than -0.35 V, and the chloride measurements were all less than the threshold value for corrosion, indicating that the reinforcing steel is not corroding.

2.3/ Deck Underside

The undersides of the deck and the girders are heavily rust stained from the chairs used to support the reinforcing steel. There are several transverse cracks in the deck slab. Most are accompanied by efflorescence, and some are associated with wet spots. Two cores taken full depth in these areas (core numbers 7-C-1 and 7-C-6) showed that the concrete is sound and the wetting is confined to the bottom 10 mm of the concrete in both cases.

2.4/ Components

Narrow, transverse cracks, rust stains and light scaling were observed on the curbs and sidewalks, especially on the outside edge of the east curb.

The approach slabs are concrete, but the slabs have settled and have been padded with hot mix a number of times. A core taken through the south approach slab revealed 110 mm of asphalt over a 255 mm concrete slab.

The only curb and gutter is on the west side of the structure, around the catch basins. It has settled about 40 mm. The curb on the approach slab at the southeast corner has settled very unevenly.

The paint is peeling from the handrail panels and posts, and it is rusting in the bare spots. The single cable guiderail is in very poor condition, and it is not attached to the structure. The cable is slack, and the posts deteriorated.

The west column of the south pier has vertical cracks approximately 1 m above ground level. The slope protection at the north abutment has slipped, resulting in a blow-up at the toe.

3/ SURVEY SUMMARY SHEET

SITE NO. 33 - 199

SURVEY SUMMARY SHEET
FOR ASPHALT-COVERED DECKS

1. DIMENSIONS OF DECK

Length between abutment joints	67.40	m
Width between curbs or sidewalks	8.54	m
	8.54	m
Deck area (riding surface only)	575.60	m²
Curb area (including median curb)	60	m²
Sidewalk area	121	m²

N	~~E~~	Abutment
S	~~W~~	

2. CRACKING (Deck only top surface)

	Unsealed	Sealed	
Transverse	43	—	m
Longitudinal			m
Random			m

3. SCALING

	Sidewalks	Curbs	
Light			m²
Medium			m²
Heavy			m²
Severe			m²

4. DELAMINATION AND SPALLING

	Sidewalks	Curbs	
Patches			m²
Open Spalls		10	m²
Delamination			m²

5. CORROSION ACTIVITY

	Min.	Max	Ave.	
Half Cell Potential	0.05	-0.33	-0.16	VCSE

0 to -.20 V	498	m²
-.21 to -.35 V	77	m²
-.36 to -.45 V		m²
-.46 to -.55 V		m²
less than -.55 V		m²

6. UNDERSIDE DETERIORATION

		Leached and/or Stained	
Cracking – Transverse	18		m
Longitudinal	—		m
Other	/	/	m
Wet Spots	28	m²	
Spalls	—	m²	
Honeycombing	—	m²	
Other	—		

REMARKS

Cracking indicated is in asphalt wearing surface.

SEE FIGURE 25

Spalls indicated are on west curb face.
SEE FIGURE 25

Wet areas, cracks with efflorescence and rust stains were evident on underside deck,
SEE FIGURES 18, 19

4/ COMPONENT INSPECTION FORMS

COMPONENT INSPECTION FORM **SITE NO.** 33 - 199

Page 1 of 2

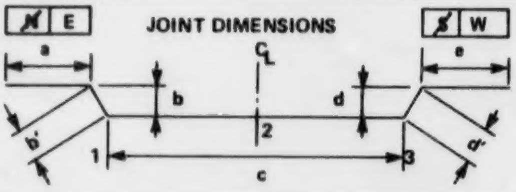
1 JOINTS

		ABUTMENTS				INTERMEDIATE	
DIMENSION		N	~~E~~	S	~~W~~		
a	m	1.76		1.76			
b	mm	284		291			
b'	mm	286		295			
c	m	8.60		8.55			
d	mm	230		230			
d'	mm	234		234			
e	m	0.85		0.84			
GAP DIMENSION							
1	mm						
2	mm						
3	mm						
EXP.							
FIXED		X		X			
TYPE							
LEAKING							
ANGLE SIZE	mm						

REMARKS

There are no expansion joints in the structure.
There is a crack in the asphalt at each abutment over the joint line between the deck and the approach slab.

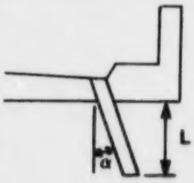
JOINT DIMENSIONS



TEMPERATURE °C	DECK	AMBIENT
	23	23

2 DRAINS

NUMBER	TYPE	LENGTH	α
None			



3 BEARINGS

	ABUTMENTS				PIERS	
	N	E	S	W		
NUMBER	None					
TYPE						
SIZE						
CONDITION *						
BEARING SEAT *						

* Condition – G = Good, F = Fair, P = Poor

COMPONENT INSPECTION FORM

Page 2 of 2

SITE NO. *33 - 199*

4 SUBSTRUCTURES

	LOCATION	CONDITION*
ABUTMENTS	*N/S*	*G/G*
BALLAST WALLS	*None*	
PIERS	*N/C/S*	*G/G/F*
SLOPE PAVING	*N/S*	*P/G*

REMARKS

Piers – Vertical cracks in E. column of S. Pier, 1 m above ground.
SEE FIGURE 22
Slippage of grouted rip-rap has resulted in blow-up at toe of north slope.
SEE FIGURE 21

5 HANDRAILS AND PARAPETS

		NUMBER	CONDITION*
PARAPET WALLS WITH 1,2 RAILS			
BARRIER WALLS			
POSTS	**CONCRETE** *End Post*	*4*	*G*
	STEEL	*46*	*F*
PANELS	**CONCRETE**		
	STEEL	*48*	*F*
OTHER			

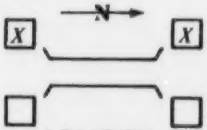
Numerous panels and posts show paint flaking and rusting. Panel near S.E. corner damaged by vehicle impact. Concrete corner posts in good condition except for rust staining at the base of the S.W. post.

6 APPROACHES

			EXPOSED CONCRETE	ASPHALT	CONDITION*
APPROACH SLABS	**YES**	*X*		*X*	*G*
	NO				
APPROACH ROAD SURFACE				*X*	*G*

CURB AND GUTTER	**YES**	*X*	**CONDITION***
	NO		*F*

			NUMBER
CATCH BASINS	**YES**	*X*	*2*
	NO		



LOCATION (SHOW NORTH)

Curb and gutter adjacent to catch basins only, settled approx. 40 mm.

The single cable guiderail is in very poor condition, cable slack and posts deteriorated or broken.

7 BEAMS

TYPE	*T-beam*
NUMBER	*6*
CONDITION*	*G*

Rust stains from chair supports on underside of all beams. Concrete in good condition.
SEE FIGURE 18

* Condition – G = Good, F = Fair, P = Poor

5/ SURVEY EQUIPMENT AND CALIBRATION PROCEDURES

SITE NO. 33 - 199

SURVEY EQUIPMENT
AND CALIBRATION PROCEDURES

SURVEY EQUIPMENT [1]

1. DELAMINATION
   weight of chain (kg/m) *2.2 kg/m with 50 mm links*
   other equipment

2. COVER
   pachometer(s) *James R. Meter, Model No. C - 4979, Serial No. 5815*

3. CORROSION ACTIVITY
   half cell *M.C. ' Miller, Model RE-3*
   voltmeter *Beckman Digital Multimeter Model 3020*
   length and gauge of lead wire *80 m, 18 Gauge*

CALIBRATION AND CHECKING

	Deck		Ambient	
Temperature at start of test	9/15	9/16	9/15	9/16
Temperature at end of test	22	18	23	14
	26	25	24	23

4. COVER
   a) Battery check
      Reading at start of test 9.2
      Reading at end of test 9.0
      Readings over 8.7 are O.K.

   b) Location of cover check *Sawn sample 5 - A - 3*
      Actual depth and size of bar *13 mm dia. 55 mm deep*
      Reading before test 55
      Reading during test [2] 55
      Reading end of test 55

5. CORROSION ACTIVITY
   a) Battery check: *O.K.*
   b) Ground – location *In sawn sample area 5 - A - 3*
      – method of connection *Self tapping screw*
      – resistance and location of check *to steel in 7 - C - 2, 3.9 Ω, to steel in 7 - C-- 8, 4.0 Ω*
      – cover at ground locations *70 mm*
   c) Grid Point Readings

LOCATION	INITIAL READING Volts, CSE	CHECK [3]
0.52, 40.5	0.30	0.30
3.52, 10.5	0.08	0.09
3.52, 40.5	0.12	0.11
5.02, 64.5	0.23	0.23
8.02, 52.5	0.06	0.05

---

[1] Give Manufacturer and Model No. where applicable

[2] At least one reading per hour of test

[3] Check at least five readings at beginning and end of test and at each change of ground.

6/ CORE PHOTOGRAPHS AND SKETCHES

Figure 4/ Site 33-199, Core 7-C-1

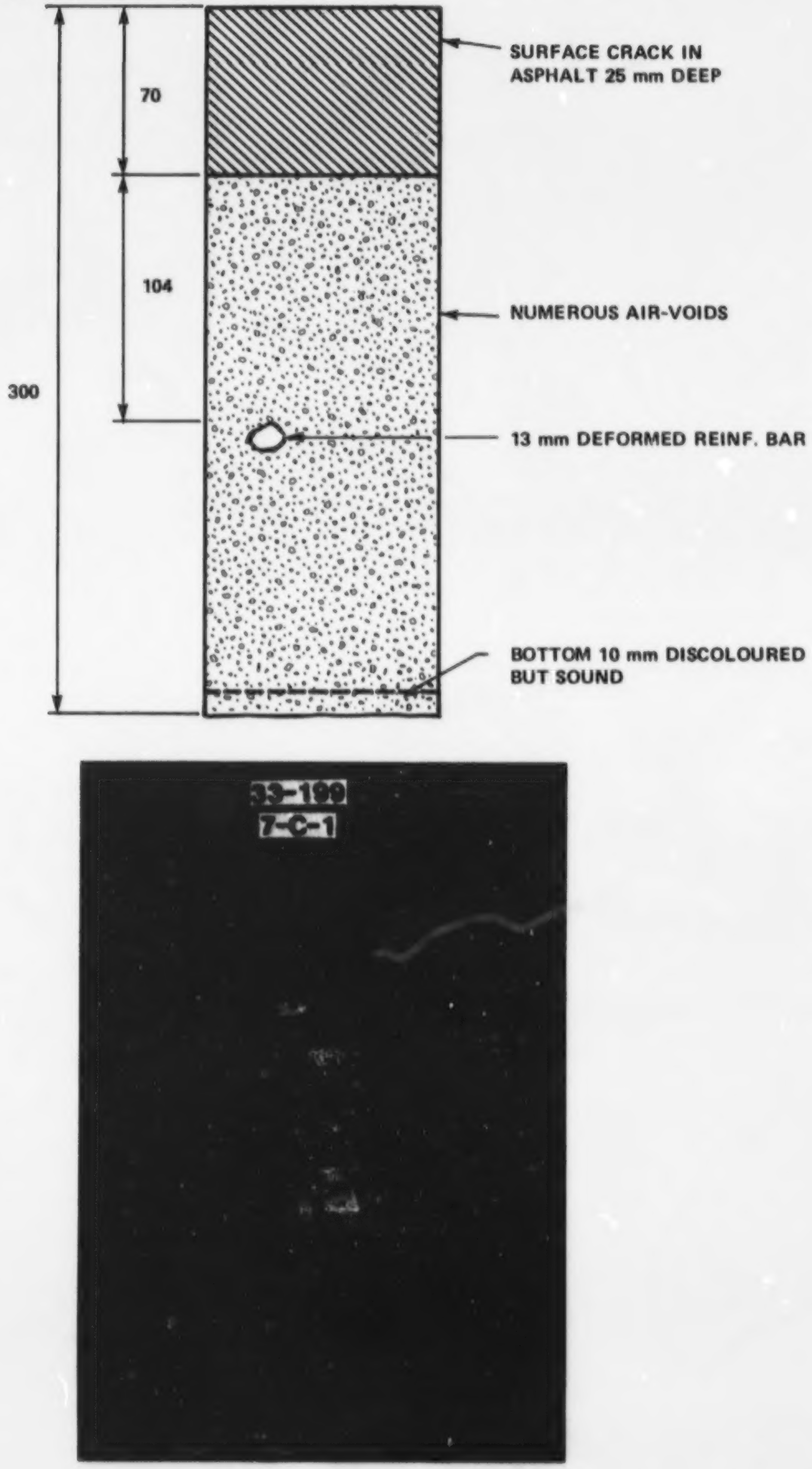

70
104
300
SURFACE CRACK IN ASPHALT 25 mm DEEP
NUMEROUS AIR-VOIDS
13 mm DEFORMED REINF. BAR
BOTTOM 10 mm DISCOLOURED BUT SOUND
33-199
7-C-1

Figure 5/ Site 33-199, Core 7-C-2

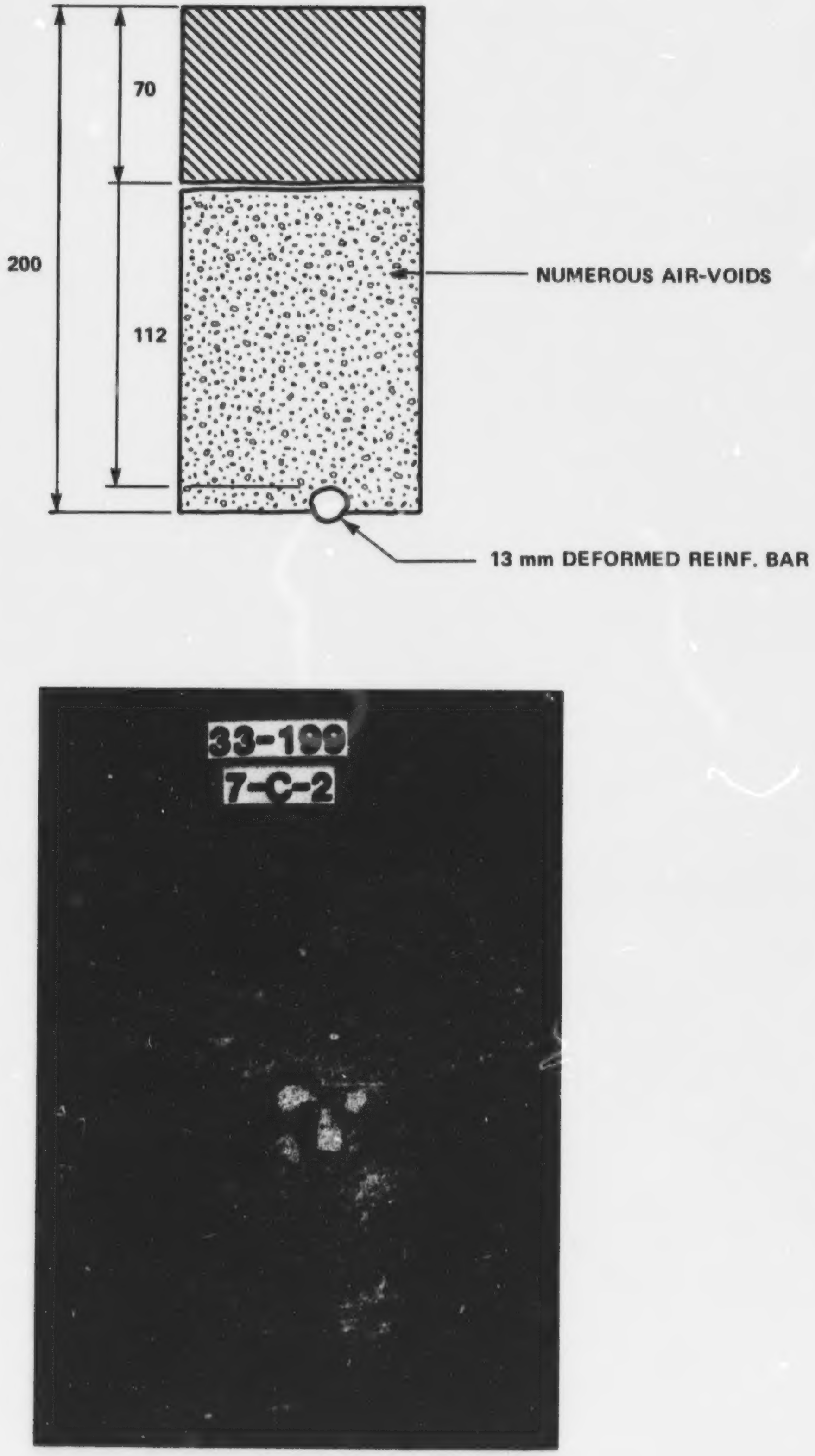

70
200
112
NUMEROUS AIR-VOIDS
13 mm DEFORMED REINF. BAR
33-199
7-C-2

Figure 6/ Site 33-199, Core 7-C-3

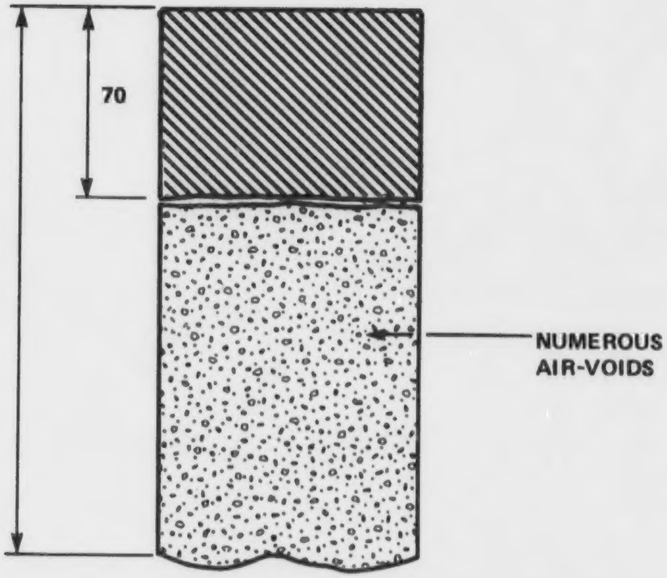

70
195
NUMEROUS AIR-VOIDS

Figure 7/ Site 33-199, Core 7-C-4

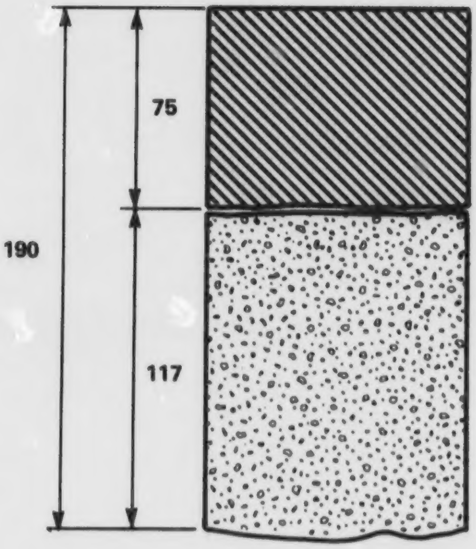


Figure 8/ Site 33-199, Core 7-C-5

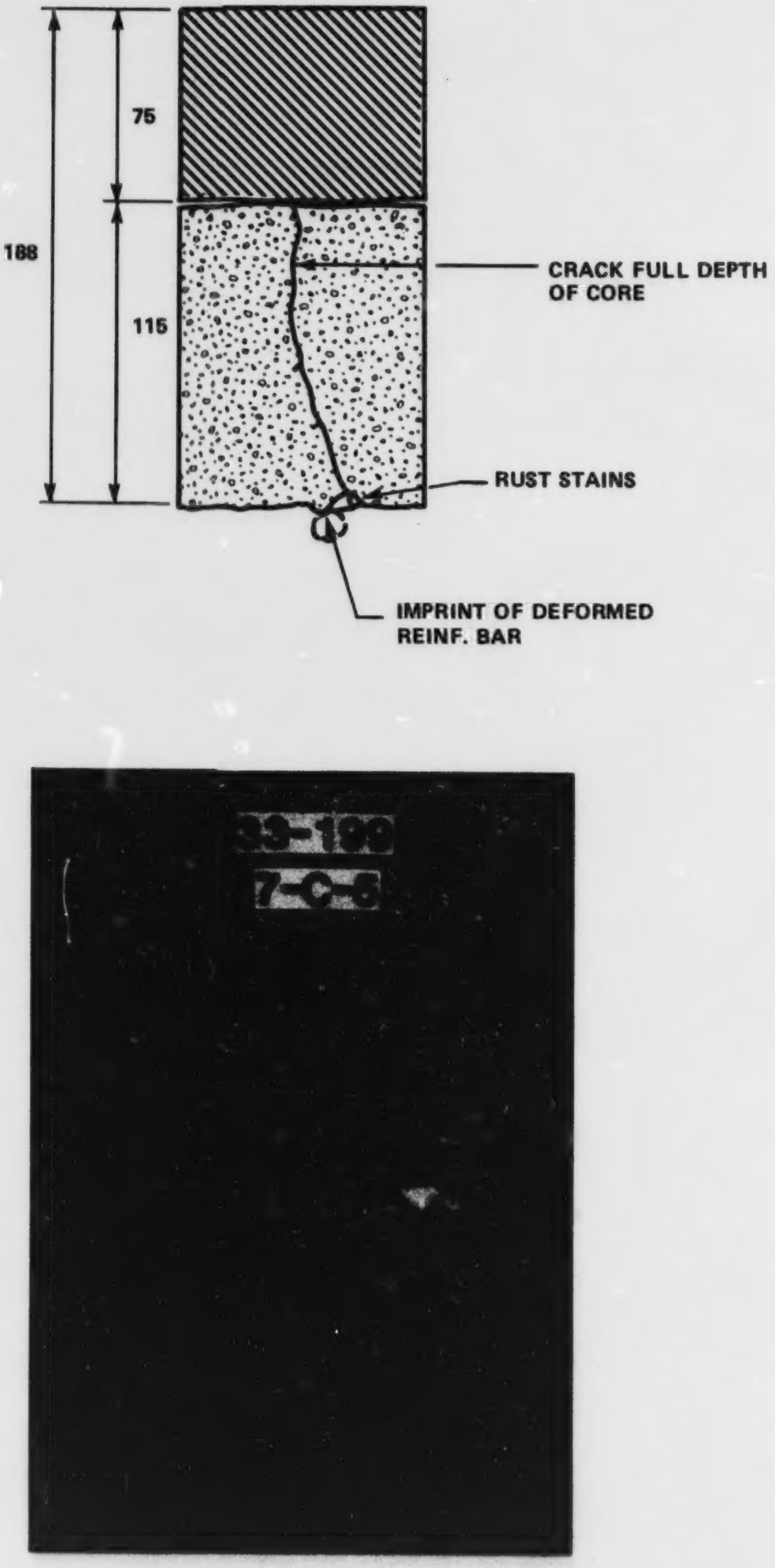

75
188
115
CRACK FULL DEPTH OF CORE
RUST STAINS
IMPRINT OF DEFORMED REINF. BAR
33-199
7-C-5

Figure 9/ Site 33-199, Core 7-C-6

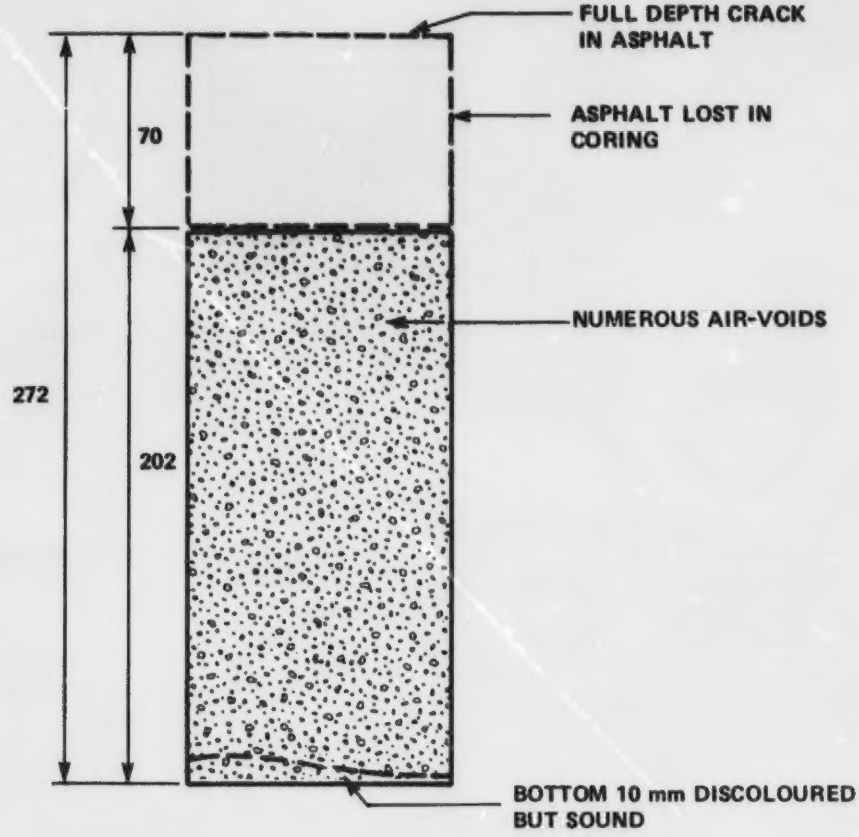

FULL DEPTH CRACK IN ASPHALT
ASPHALT LOST IN CORING
NUMEROUS AIR-VOIDS
BOTTOM 10 mm DISCOLOURED BUT SOUND
70
202
272

Figure 10/ Site 33-199, Core 7-C-7

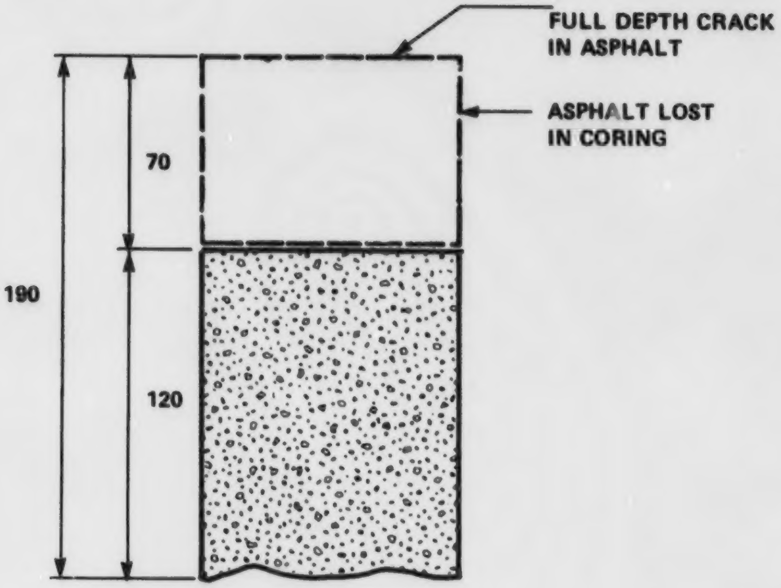

FULL DEPTH CRACK IN ASPHALT
ASPHALT LOST IN CORING
70
190
120

Figure 11/ Site 33-199, Core 7-C-8

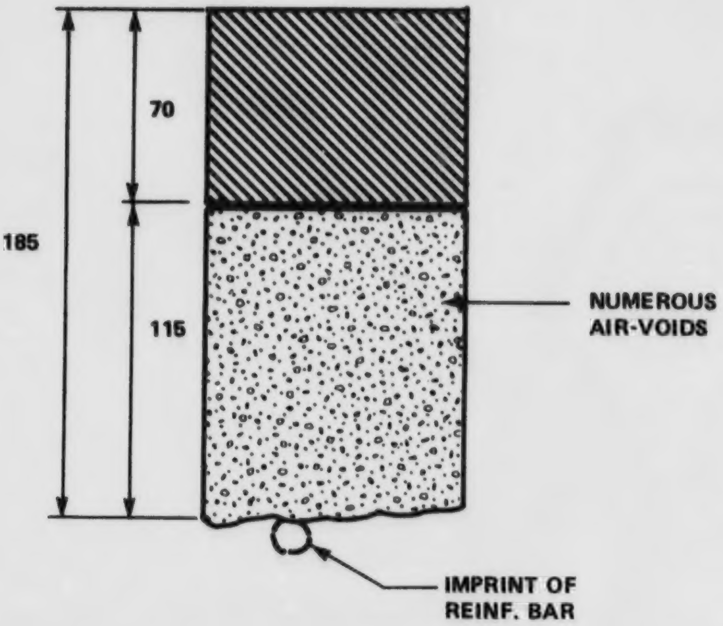
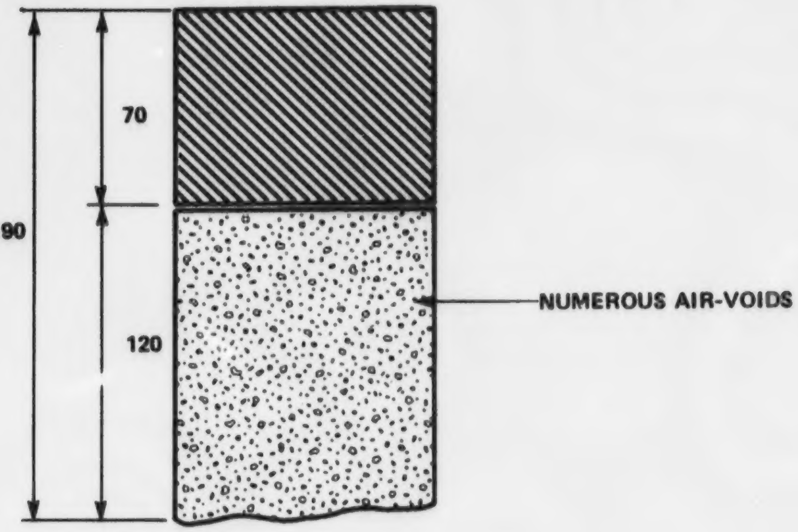

70
185
115
NUMEROUS AIR-VOIDS
IMPRINT OF REINF. BAR

Figure 12/ Site 33-199, Core 7-C-9


70
190
120
NUMEROUS AIR-VOIDS

CORE LOG
ASPHALT-COVERED BRIDGE DECKS

SITE NO. 33 - 199

Page 1 of 4

CORE NO.	7 - C - 1	7 - C - 2	7 - C - 3
LOCATION	G.L. 2.8 Stn. 1.0	G.L. 1.0 Stn. 43.5	G.L. 2.02 Stn. 22.5
DIAMETER, mm	100	100	100
THICKNESS OF ASPHALT, mm	70	70	70
THICKNESS OF CONCRETE, mm	230	130	130
FULL DEPTH (YES/NO)	Yes	No	No
CONDITION OF ASPHALT*	G	G	G
TYPE OF WATERPROOFING	None	None	None
CONDITION OF WATERPROOFING*	—	—	—
BOND OF W/P TO ASPHALT	—	—	—
BOND OF ASPHALT OR W/P TO CONCRETE	Good	Poor	Poor
DEFECTS IN CORE	Numerous air-voids	Numerous air-voids	Numerous air-voids
QUALITY OF CONCRETE	Good	Good	Good
COMPRESSIVE STRENGTH, MPa			
CHLORIDE CONTENT % Cl by weight of concrete — Depth 0 – 10 mm 20 – 30 mm 40 – 50 mm 60 – 70 mm 80 – 90 mm	Not Tested	Not Tested	Not Tested
AIR-VOIDS Air content, % Specific surface, mm⁻¹ Spacing factor, mm			4.5 12.2 0.37
TESTING LABORATORY	Construction Services Ltd., 5963 Universal Drive, Mississauga		
REMARKS	Surface crack in asphalt, 25 mm deep		

* Condition – G = Good, F = Fair, P = Poor W/P – denotes waterproofing

CORE LOG
ASPHALT-COVERED BRIDGE DECKS

SITE NO. 33 - 199

Page 2 of 4

CORE NO.	7 - C - 4	7 - C - 5	7 - C - 6
LOCATION	℄, Stn. 49.5	G.L. 6.4 Stn. 30.5	G.L. 5.5 Stn. 65.5
DIAMETER, mm	100	100	100
THICKNESS OF ASPHALT, mm	75	75	70
THICKNESS OF CONCRETE, mm	117	113	202
FULL DEPTH (YES/NO)	No	No	Yes
CONDITION OF ASPHALT*	G	G	G
TYPE OF WATERPROOFING	None	None	None
CONDITION OF WATERPROOFING*	—	—	—
BOND OF W/P TO ASPHALT	—	—	—
BOND OF ASPHALT OR W/P TO CONCRETE	Poor	Poor	Poor
DEFECTS IN CORE	None	Narrow vertical crack, full depth of core	Numerous air-voids
QUALITY OF CONCRETE	Good	Good	Good
COMPRESSIVE STRENGTH, MPa			42.6
CHLORIDE CONTENT % Cl by weight of concrete — Depth 0 – 10 mm		.026	
20 – 30 mm		.024	
40 – 50 mm		.023	
60 – 70 mm		.023	
80 – 90 mm		.022	
AIR-VOIDS Air content, %			
Specific surface, mm^{-1}			
Spacing factor, mm			
TESTING LABORATORY	Construction Services Ltd., 5963 Universal Drive, Mississauga		
REMARKS			Asphalt destroved in coring, full depth crack in asphalt

* Condition – G = Good, F = Fair, P = Poor W/P – denotes waterproofing

CORE LOG
ASPHALT-COVERED BRIDGE DECKS

SITE NO. 33 - 199

Page 3 of 4

CORE NO.	*7 - C - 7*	*7 - C - 8*	*7 - C - 9*
LOCATION	*G.L. 8.0 Stn. 2.0*	*G.L. 8.02 Stn. 59*	*G.L. 8.02 Stn. 36*
DIAMETER, mm	*100*	*100*	*100*
THICKNESS OF ASPHALT, mm	*75*	*70*	*70*
THICKNESS OF CONCRETE, mm	*140*	*110*	*113*
FULL DEPTH (YES/NO)	*No*	*No*	*No*
CONDITION OF ASPHALT*	*G*	*G*	*G*
TYPE OF WATERPROOFING	*None*	*None*	*None*
CONDITION OF WATERPROOFING*	—	—	—
BOND OF W/P TO ASPHALT	—	—	—
BOND OF ASPHALT OR W/P TO CONCRETE	*Poor*	*Poor*	*Poor*
DEFECTS IN CORE	*None*	*Numerous air-voids*	*Numerous air-voids*
QUALITY OF CONCRETE	*Good*	*Good*	*Good*
COMPRESSIVE STRENGTH, MPa			*40.3*
CHLORIDE CONTENT % Cl by weight of concrete — Depth 0 – 10 mm	*.028*		
20 – 30 mm	*.027*		
40 – 50 mm	*.023*		
60 – 70 mm	*.023*		
80 – 90 mm	*.018*		
AIR-VOIDS — Air content, %			
Specific surface, mm^{-1}			
Spacing factor, mm			
TESTING LABORATORY	*Construction Services Ltd., 5963 Universal Drive, Mississauga*		
REMARKS	*Asphalt destroyed in coring. Full depth crack in asphalt.*		

* Condition – G = Good, F = Fair, P = Poor W/P – denotes waterproofing

CORE LOG
ASPHALT-COVERED BRIDGE DECKS

SITE NO. 33 - 199

Page 4 of 4

CORE NO.	7 - C - 10		
LOCATION	Approach slab, 3 m from expansion joint at south end.		
DIAMETER, mm	100		
THICKNESS OF ASPHALT, mm	110		
THICKNESS OF CONCRETE, mm	255		
FULL DEPTH (YES/NO)	Yes		
CONDITION OF ASPHALT*	G		
TYPE OF WATERPROOFING	None		
CONDITION OF WATERPROOFING*			
BOND OF W/P TO ASPHALT			
BOND OF ASPHALT OR W/P TO CONCRETE			
DEFECTS IN CORE	None		
QUALITY OF CONCRETE	Good		
COMPRESSIVE STRENGTH, MPa			
CHLORIDE CONTENT Depth % Cl by weight of concrete 0 – 10 mm 20 – 30 mm 40 – 50 mm 60 – 70 mm 80 – 90 mm			
AIR-VOIDS Air content, % Specific surface, mm^{-1} Spacing factor, mm			
TESTING LABORATORY			
REMARKS			

* Condition – G = Good, F = Fair, P = Poor W/P – denotes waterproofing

8/SAWN ASPHALT SAMPLE LOG

SITE NO. 33 - 199

Page 1 of 1

SAWN ASPHALT SAMPLE LOG

SAMPLE NO.	*5 - A - 1*	*5 - A - 2*	*5 - A - 3*
LOCATION	*G.L. 0.52 Stn. 55.5*	*G.L. 5.8 Stn. 28.5*	*℄. Stn. 7.5*
SIZE, mm x mm	*300 x 600*	*300 x 600*	*300 x 600*
THICKNESS OF ASPHALT, mm	*95*	*80*	*75*
CONDITION OF ASPHALT*	*G*	*G*	*F*
TYPE & THICKNESS OF W/P, mm	*None*	*None*	*None*
CONDITION OF W/P*	—	—	—
BOND OF W/P TO ASPHALT	—	—	—
BOND OF ASPHALT OR W/P TO CONCRETE	*Poor*	*Poor*	*Poor*
CONCRETE COVER TO REINF., mm	*40*	*50*	*55*
CONDITION OF CONCRETE SURFACE	*– water standing on surface* *– rough* *– light scaling*	*– dry* *– rough* *– light scaling*	*– dry* *– rough* *– no scaling*
REMARKS			*Full depth crack through asphalt.*

* Condition – G = Good, F = Fair, P = Poor W/P – denotes waterproofing

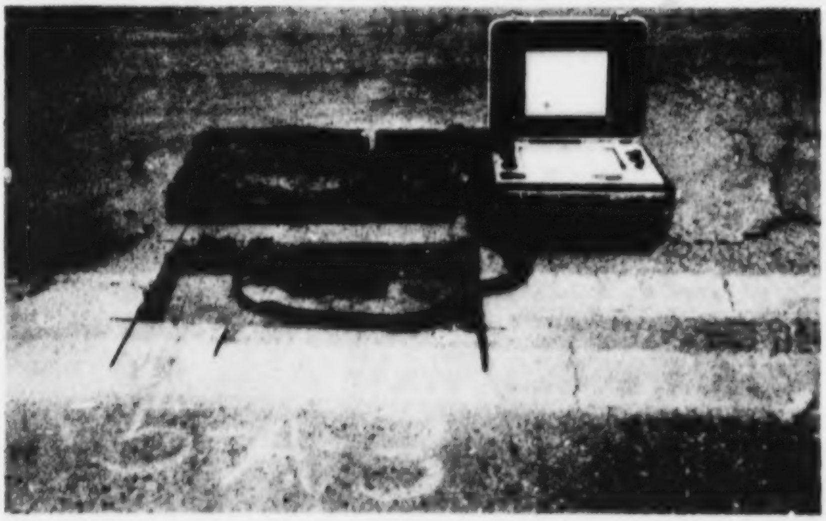
9/SAWN ASPHALT SAMPLE PHOTOGRAPHS

ESMERALDA TWP 7th LINE UNDERPASS **SITE 33-199, HWY. 401**

**Figure 13/
Sawn Sample, 5-A-1**

**Figure 14/
Sawn Sample, 5-A-2**

**Figure 15/
Sawn Sample, 5-A-3**



10/ SITE PHOTOGRAPHS

ESMERALDA TWP 7th LINE UNDERPASS **SITE 33-199, HWY. 401**

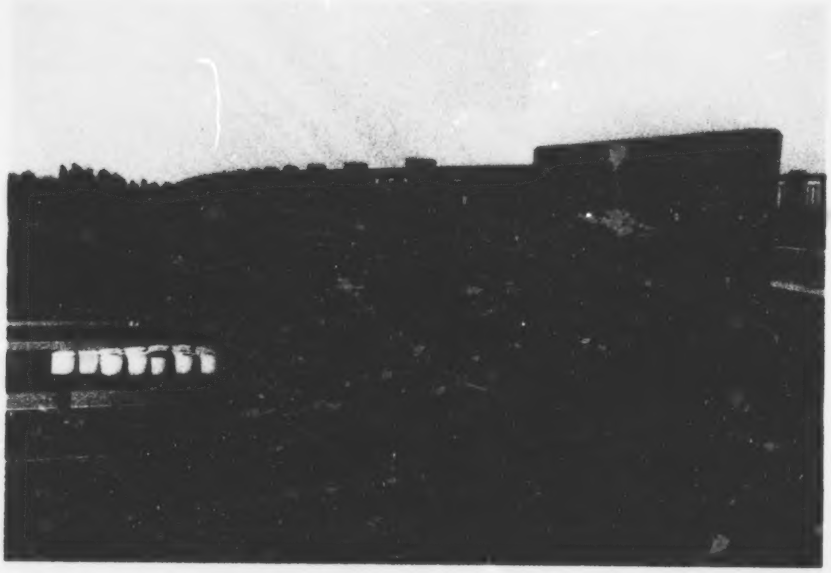


**Figure 16/
West Elevation
Looking North**

**Figure 17/
Looking North**

Figure 18/ Wet Areas on Soffit—South Span; Note Rust Stains from Rebar Chairs

Figure 19/ Wet Area and Rust Stains Near South Abutment Between Girders

Figure 20/ Crack in Pavement at End of Approach Slab (TYP.)

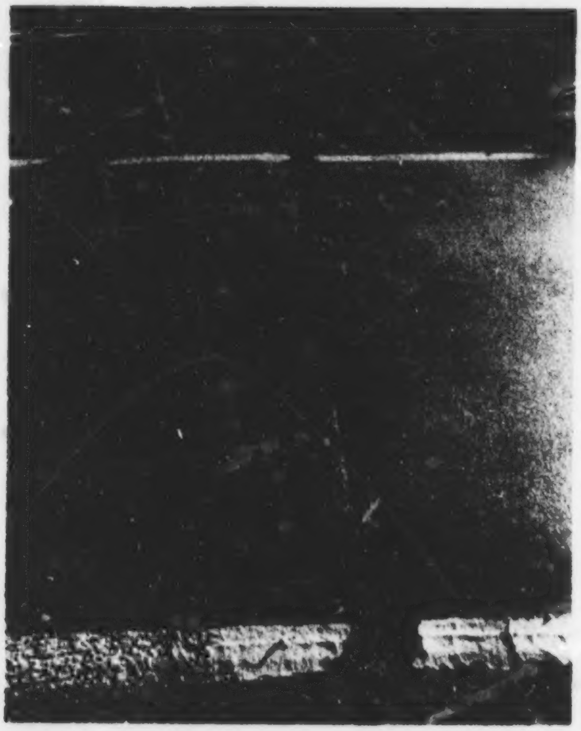


Figure 21/
Slope Protection at
North Has Slipped

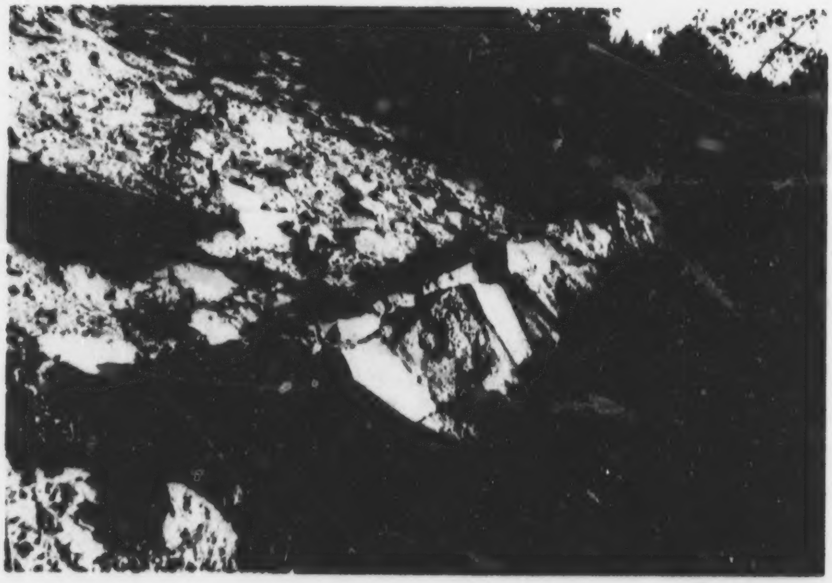


Figure 22/ Deterioration of East Pier Column—South Pier

Figure 23/ South Abutment

Figure 24/
Rusting on Handrail Posts and Panels

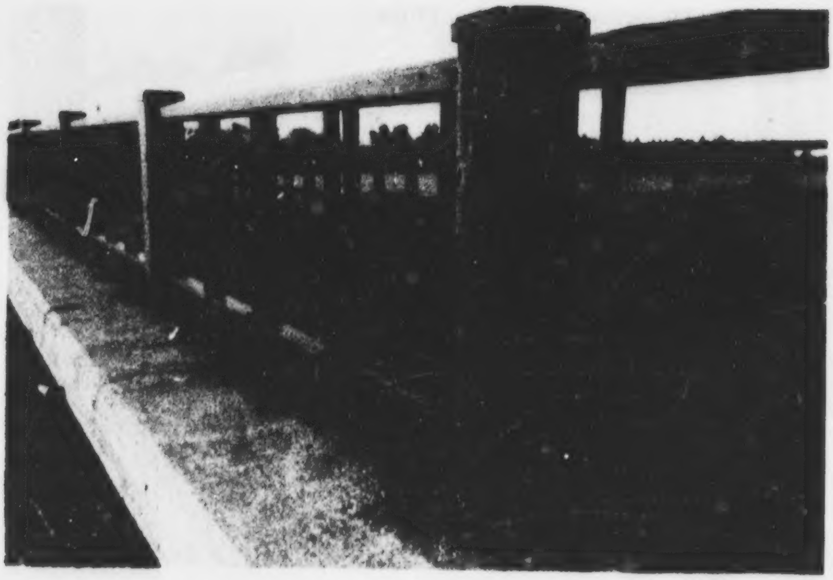
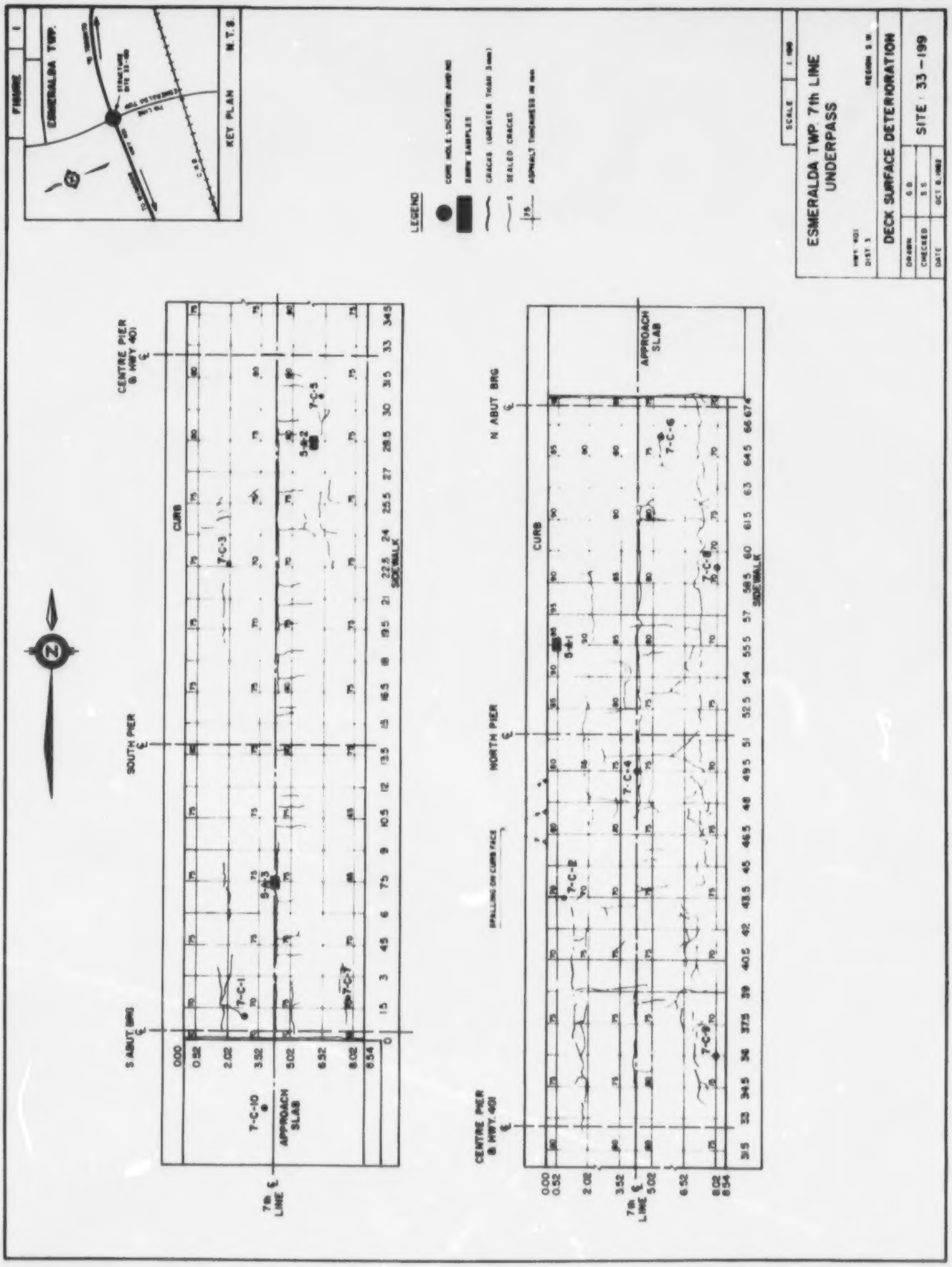


Figure 25/
Minor Spalls on West Curb Face

11/ SITE DRAWINGS


ESMERALDA TWP. 7th LINE
UNDERPASS
DECK SURFACE DETERIORATION
SITE : 33-199
KEY PLAN
N.T.S.
FIGURE
LEGEND
CURB
SIDEWALK
APPROACH SLAB
S ABUT BRG
SOUTH PIER
CENTRE PIER @ HWY 401
NORTH PIER
N ABUT BRG
7th LINE
SPALLING ON CURB FACE
7-C-1
7-C-2
7-C-3
7-C-4
7-C-5
7-C-6
7-C-7
7-C-8
7-C-9
7-C-10
S-R-1
S-R-2
S-R-3

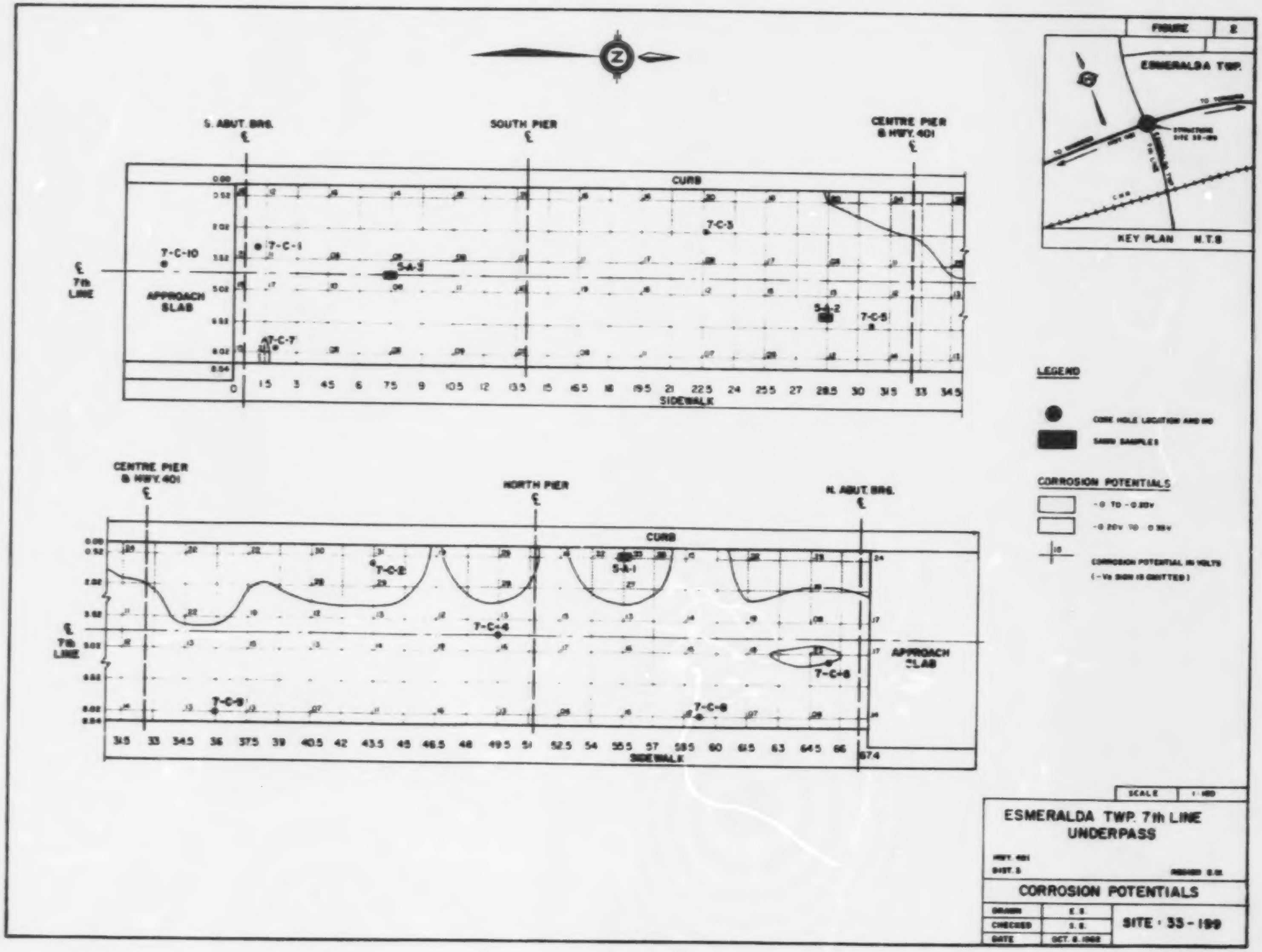


FIGURE 2
ESMERALDA TWP.
KEY PLAN N.T.S.
S. ABUT. BRG. ℄
SOUTH PIER ℄
CENTRE PIER & HWY. 401 ℄
NORTH PIER ℄
N. ABUT. BRG. ℄
CURB
SIDEWALK
APPROACH SLAB
℄ 7th LINE
7-C-1
7-C-2
7-C-3
7-C-4
7-C-5
7-C-6
7-C-7
7-C-8
7-C-9
7-C-10
S-A-1
S-A-2
S-A-3
0.00
0.52
2.02
3.52
5.02
6.52
8.02
8.54
0
1.5
3
4.5
6
7.5
9
10.5
12
13.5
15
16.5
18
19.5
21
22.5
24
25.5
27
28.5
30
31.5
33
34.5
36
37.5
39
40.5
42
43.5
45
46.5
48
49.5
51
52.5
54
55.5
57
58.5
60
61.5
63
64.5
66
67.4
LEGEND
CORE HOLE LOCATION AND NO.
SAWN SAMPLES
CORROSION POTENTIALS
-0 TO -0.20v
-0.20v TO 0.35v
CORROSION POTENTIAL IN VOLTS
(-Ve SIGN IS OMITTED)
SCALE 1:100
ESMERALDA TWP. 7th LINE UNDERPASS
HWY. 401
DIST. 5
CORROSION POTENTIALS
DRAWN E.S.
CHECKED S.S.
DATE OCT. 6, 1982
SITE : 33-199

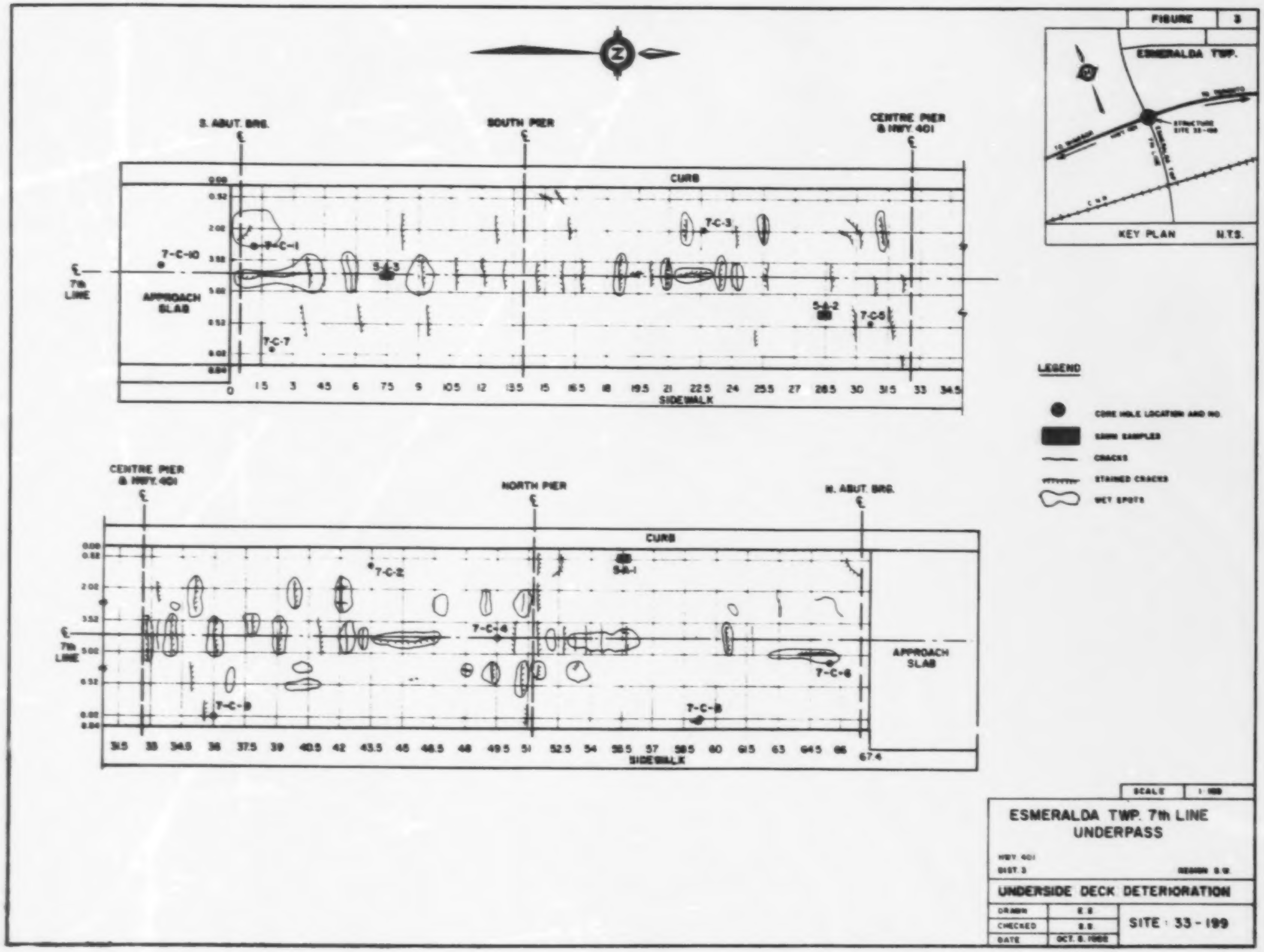

S. ABUT. BRG.
SOUTH PIER
CENTRE PIER & HWY. 401
CURB
SIDEWALK
APPROACH SLAB
7th LINE
7-C-10
7-C-1
7-C-7
7-C-3
7-C-5
5-A-3
5-A-2
0.00
0.52
2.02
3.52
5.02
6.52
8.02
8.84
0
1.5
3
4.5
6
7.5
9
10.5
12
13.5
15
16.5
18
19.5
21
22.5
24
25.5
27
28.5
30
31.5
33
34.5
CENTRE PIER & HWY. 401
NORTH PIER
N. ABUT. BRG.
7-C-2
7-C-4
7-C-9
7-C-8
7-C-6
5-A-1
31.5
33
34.5
36
37.5
39
40.5
42
43.5
45
46.5
48
49.5
51
52.5
54
55.5
57
58.5
60
61.5
63
64.5
66
67.4
LEGEND
CORE HOLE LOCATION AND NO.
50mm SAMPLES
CRACKS
STAINED CRACKS
WET SPOTS
ESMERALDA TWP.
STRUCTURE SITE 33-199
HWY 401
7th LINE
TO TORONTO
TO WINDSOR
C.N.R.
KEY PLAN
N.T.S.

FIGURE 3

SCALE 1:100

ESMERALDA TWP. 7th LINE
UNDERPASS

HWY 401
DIST. 3
REGION S.W.

UNDERSIDE DECK DETERIORATION

DRAWN E.S.
CHECKED S.S.
DATE OCT. 6. 1988

SITE : 33 - 199

8/ REVIEW OF THE REPORT

8.1/ Introduction

Bridge Deck Condition Surveys for the Ministry will normally be carried out by consulting engineers. When the report is received it is necessary that it be reviewed and formally accepted. Omissions and anomalies should be resolved prior to approving final payment for the work. The following guidelines have been prepared in the form of a checklist for each section of the report which will aid in the review and assist in identifying inconsistencies in the data. Some of the items apply only to either exposed concrete or asphalt-covered decks. The same guidelines should be applied in an independent review of any surveys carried out in-house.

It is recommended that the reviewer mark off the material corresponding to each item in the checklist on one copy of the report.

8.2/ Reference Data

The reviewer needs to be familiar with the following:

- existing structure drawings,
- consultant's agreement,
- sample reports,
- maintenance inspection file, and
- ASTM C876.

8.3/ Structure Identification Sheet

The following information should appear on this sheet:

- structure data—type of structure, no. of spans etc.;
- date of survey—for realistic temperatures at time of year, and in relation to restrictions in temperature for half cell testing;
- time spent at site—is it reasonable?; and
- year built—significant points about age.

8.4/ Summary of Significant Findings

The findings should:

- be written by the engineer responsible (P.Eng.) and stamped;
- summarize all significant deterioration and also include forms and photographs;
- explain any relationship between spalling, delamination, cover and corrosion potentials;
- include any relationship between scaling, air-void system and year of construction; and
- explain unusual defects, inconsistent data or unexpected results.

8.5/ Survey Summary Sheet

8.5.1/ Dimensions

Ensure that:

- the dimensions are correct; and
- the photographs, captions and plans agree with the existing drawings of the structure.

8.5.2/ Cracking

Check for:

- any relationship between significant cracks and structural problems (e.g. settlement, excessive deflection);
- consistency between total length of cracking in each category and the plan; and
- a written explanation in the summary of any significant or unusual cracks.

8.5.3/ Scaling

If scaling is present:

- check the age of the structure and the air-void system;
- confirm that there is a photograph of significant scaling;
- verify that photographs of scaling do not show spalling, wear or grinding; and
- ensure that, if there is a significant amount, it is discussed in the written summary.

8.5.4/ Delamination and Spalling

Check that:

- there are photographs of major spalls (typical);
- the total areas agree with the plan; and
- there is a relationship between areas of delamination and spalling, low cover and high corrosion potentials. If not, is there an explanation.

8.5.5/ Concrete Cover

Check that:

- the cover measurements follow a normal frequency distribution;
- the areas within each increment agree with the plan, and the total area agrees with the deck area;
- there are no uniformly low (< 30 mm) and uniformly high (> 70 mm) readings. Readings of 100 mm or more are very uncommon, except on some rigid frames, and may indicate that the cover has not been measured to the uppermost bar;
- sudden variations in cover from one grid point to the next are explained; and
- cover measurements on the plans agree with covers shown in cores at the corresponding locations.

8.5.6/ Corrosion Activity

Ensure that:

- the readings follow a normal frequency distribution;
- the areas within each increment agree with the plan, and the total area agrees with the deck area;
- areas of high corrosion activity coincide with delaminations and spalls; and
- an explanation is provided for any suspicious uniformly low (> -0.20 V) or uniformly high (< -0.40 V) readings.

8.5.7/ Underside Deterioration

Where there is underside deterioration check that:

- there are photographs of significant deterioration;
- the written summary is consistent with both the totals given in the Summary Sheet and the photographs; and
- the figures agree with the plan.

8.6/ Component Inspection Form

8.6.1/ Joints

For joints ensure that:

- dimensions and orientation agree with original structure drawings;
- deterioration or unusual features shown in the photographs appear in the remarks;
- there is a relationship between gap, temperature and time of year; and
- joints are clearly shown on the plan.

8.6.2/ Drains

- Ensure that the actual number of drains corresponds with number shown on the plans.

8.6.3/ Bearings, Substructures, Parapets, Approaches and Beams

- Ensure that defects are illustrated and discussed in the written summary.

8.6.4/ Survey Equipment and Calibration Procedures

Ensure that:

- equipment is suitable (see Appendix C);
- temperatures are high enough for corrosion testing;
- resistance to ground is less than 10Ω (preferably less than 5Ω) and location is recorded; and
- there is a separate ground location for each part of a discontinuous slab (note location of all joints in deck slab).

8.7/ Core Log

For the Core Log check that:

- the number of cores conforms to the agreement;
- the cores are well distributed over deck surface;
- the cores are taken in suspected areas of deterioration—cracking, high potentials, deep delamination;
- one core is full depth;
- core photographs are taken in a laboratory environment;
- photographs and dimensional sketches show the same view;
- photographs and the Core Log agree;
- testing is done by approved laboratories;
- compression tests are done on cores where there is an L/D of 1.0 and there is no steel;
- air-void measurements are done only on structures built in 1958 and later, and the spacing factor, specific surface and air content are reported;
- number of chloride measurements conforms to the agreement and any anomalous values are explained; and
- where requested, approach slab and curb or sidewalk cores have been taken.

8.8/ Sawn Samples

For sawn samples check that:

- the number conforms to agreement;
- the samples are well distributed and that some are located in areas of suspected deterioration (e.g. cracks or wet spots on underside);
- there is dry sawing (examine photographs carefully);
- asphalt thickness agrees with photographs and thickness shown at adjacent grid points (cores should also be checked this way); and
- photographs and description of concrete deck slab agree.

8.9/ Photographs

Check that:

- these conform to the agreement; and
- the clarity is acceptable.

8.10/ Drawings

Check that:

- these conform to the agreement and are clear and legible;
- each drawing has a clear and unambiguous legend;
- deck drains, cores and sawn samples are shown on all drawings;
- void drains are shown on underside plan;
- potential readings are given at intermediate points where differences exceed 0.15 V;
- contours have been drawn properly; and
- asphalt thickness is shown at grid points and values are reasonable.

Where it is stated that the values given in the Survey Summary Sheet should agree with the drawings, it is intended that the reviewer will check that the figures are reasonable but will not measure the drawings. Similarly, reference to a normal frequency distribution only indicates that a bell curve distribution is usually expected and departures should be explained.

Where the reviewer identifies errors, omissions or unexplained anomalies, clarification and correction shall be sought from the engineer responsible. In some cases, this may involve additional field work. Where the work is done by consulting engineers, the final invoice should not be approved until the report is satisfactory to the reviewer and written acceptance has been given.

In addition to reviewing the report for conformance with the agreement, the reviewer should be alert for conditions which may require remedial action prior to the rehabilitation contract. Where necessary, appropriate action should be taken.

9/ REFERENCE PUBLICATIONS

9.1/ Ministry Publications

1/ Manning, D.G. and Ryell, J., "Durable Bridge Decks" RR203 (1976)

2/ Task Force on Durable Bridge Decks, Activities During 1976 and 1977 (1978).

3/ Manning, D.G. and Owens, M.J., "Ontario's Experience With Concrete Overlays for Bridge Decks", ME-79-01 (1979). Also published in RTAC Forum, Vol. 2, pp 31 - 37 (1979).

4/ Manning, D.G. and Ryell, J., "A Strategy for the Rehabilitation of Concrete Bridge Decks", ME-79-02 (1979). Also published in RTAC Forum, Vol. 3, No. 4 LPP 75-82 (1981).

5/ Evers, R.C., "Manual for Bridge Deck Waterproofing" (1979).

6/ Manning, D.G. and Holt, F.B., "Detecting Delamination in Concrete Bridge Decks", ME-80-82. Also published in Concrete International Vol. 2, pp. 34 - 41 (Nov. 1980).

7/ Manning, D.G. and Northwood, R. P., "The Rehabilitation of Structures on an Urban Freeway", ME-80-01. Also published in Proceedings, Bridge Maintenance and Rehabilitation Conference, Morgantown, West Virginia, pp. 644 - 668 (1980).

8/ Manning, D.G. and Holt, F.B., "Detecting Deterioration in Asphalt-Covered Bridge Decks", ME-82-03. Also published in Transportation Research Record No. 899, pp.10-20 (1983).

9/ Chong, G.J., Phang, W.A. and Wrong, G.A., "Manual for Condition Rating of Flexible Pavements—Distress Manifestations", SP-004 (1982).

10/ Ontario Highway Bridge Design Code, Second Edition, (1983).

11/ Bridge Inspection Manual (in preparation).

9.2/ Other Publications

1/ "Guide for Making a Condition Survey of Concrete in Service," ACI Committee 201, Journal of American Concrete Inst. Vol. 65, pp. 905 -918 (1968)

2/ "Durability of Concrete Bridge Decks", NCHRP Synthesis of Highway Practice, No. 57, Transportation Research Board (1979)

APPENDIX A/ STANDARD CONSULTANT'S AGREEMENT FOR DETAILED BRIDGE DECK CONDITION SURVEYS

Introduction to Appendix A

The Ministry's Consultant's Agreement is in three parts:

Article 1	General Conditions
Article 2	Services
Article 3	Fees and Disbursements

This Appendix covers only Article 2, which comprises the technical aspects of the work.

Before preparing an agreement for work as specified in this Appendix, the issuer should ensure that the work described will satisfy the objectives and is appropriate for the structure to be investigated. Guidelines for the use of the agreement are given in Section 3.1. In addition, the following items should be specified where necessary:

- if a core is required from the approach slab (Items A8 and B7)
- if cores are required from curbs or sidewalks (Items A9 and B8)
- designation of traffic control arrangements (Item 2.3)
- designation of Consultant's working hours (Item 2.3)
- designation of concrete bridge decks to be investigated (Item 2.3)

ARTICLE 2/ SERVICES

2.1/ Consultant's Services

The Consultant shall produce four copies of a detailed report on the condition of each structure listed in Appendix A of the Agreement. The objective shall be to provide sufficient information to select the method and prepare the contract documents for the repair of the structure. The work shall be under the direct supervision of a Professional Engineer registered in the Province of Ontario, experienced in the inspection and testing of bridges. It is expected that the Engineer will be present on-site to direct the investigation, to determine the number and location of samples and to modify the course of the investigation as it progresses. The Consultant's services shall be to inspect, test, and document the condition of each structure as follows.

A/For Exposed Concrete Deck Slabs

1) Record and measure (area and location) patched and open spalls on the upper deck surface, curbs and sidewalks.

2) Determine and measure delaminated areas on the upper deck surface, curbs and sidewalks, using a chain drag or similar sounding technique.

3) Record and measure scaled areas on the upper deck surface, curbs and sidewalks, and classify by visual assessment into the degree of severity according to the following scale.

Severity of Scaling	Depth, mm
light	0 to 5
medium	5 to 10
heavy	10 to 25
severe	over 25

Care shall be taken to distinguish between scaling, wear and grinding.

4) Record significant cracks on the uppermost deck surface according to the following scale.

Severity of Cracking	Crack Width, mm
narrow (N)	less than 0.3
medium (M)	0.3 to 1
wide (W)	greater than 1

The width of cracks shall be estimated and not measured.

5) Measure the concrete cover to the top layer of reinforcing bars, based on a 3 m square grid of the deck surface, using a pachometer. The value recorded shall be the cover to the uppermost bar nearest to the intersection of the grid lines. The pachometer shall be calibrated on site and the calibration values recorded on the Survey Equipment and Calibration Procedures Form.[1]

6) Determine the corrosion activity of the top mat of reinforcing steel using a copper-copper sulphate half cell survey based on a 1.5 m square grid of the deck surface. The test method shall be ASTM C876. The deck shall be surface dry at the time of test. It is recommended that this test not be performed at temperatures less than 10°C and shall not be carried out unless the air and deck temperature is at least 5°C. The deck temperature shall be measured 50 mm below the concrete surface. Where the difference in potential between adjacent grid points is 0.15 V or greater, the potential half way between the grid points shall be recorded (except within 1 m of a joint). This procedure shall be repeated until readings between adjacent points do not exceed 0.15 V. All readings shall be taken on grid lines.

   The following information shall be recorded:

   i) the temperature and time when the test is begun and completed;
   ii) the location and method of connection to ground – a separate ground connection is required wherever the deck slab is not structurally continuous; and
   iii) the method of checking and the value of resistance of the ground connection.

7) Take cores to determine the general condition of the concrete, the nature of the defects and to obtain specimens for laboratory testing. It is expected that the cores will be representative of the condition of the concrete in the deck slab and will include cores taken in areas of deterioration or suspected deterioration (including cracks, wet spots on the deck underside and areas of high potential). It is further expected that the cores will be taken from widely separated locations on the deck surface. The cores shall be 100 mm in diameter. One of the cores shall be taken the full depth of the deck slab (except for thick slabs); the remainder shall be long enough to carry out the required tests. A pachometer will normally be used to avoid coring through the top mat of steel. Cores shall not be taken through prestressing steel. The number of cores shall not be less than 1 nor more than 4 per 200 m^2. of deck area with a minimum of 3 per structure. It is expected that the number of cores taken from decks in poor condition will approach the maximum, with the majority taken in areas of deterioration.

8) When specifically requested by the Ministry, one core shall be taken at one end of the structure near the centreline of the highway and approximately 3 m from the deck joint

to establish whether a concrete approach slab is present. The thickness of the asphalt and concrete (if present) shall be reported. No testing is required on this core.

9) Where it is known that rehabilitation will involve removal of a curb or sidewalk, at least two cores shall be taken from each side of the bridge to establish the quality of the bond with the deck slab. Cores shall not be taken through utility ducts. No physical testing is required on these cores. The cores shall only be taken when specifically requested by the Ministry.

10) Inspect and record defects on the underside of the deck surface, including significant cracks spalling, wet spots, leaching, honeycombing and exposed reinforcement. Where warranted by the degree of deterioration, the work shall be performed from a boat or bucket truck or other appropriate means of access to the deck soffit. The location of void drains shall be noted.

11) Complete the Component Inspection Form[1]. The following information shall be recorded:
   - i) joint type, and measurement of length, curb height, width, gap (and temperature at the time of measurement);
   - ii) deck drain size, number, location and condition—the length and inclination of the pipes to the vertical shall be estimated and recorded;
   - iii) bearing type, number, size and condition—where access is difficult, further instruction shall be sought from the Ministry; and
   - iv) condition of beams, barrier walls, handrail posts, bridge approaches, piers, abutments, ballast walls, slope protection and other components appropriate to future repair and rehabilitation programs.

   It is the intent that the condition of components other than the deck will be assessed and recorded only in so far as future rehabilitation is affected. Physical testing on these components is not required.

12) Colour photographs shall be taken of:
   - i) a general view of the deck surface;
   - ii) a side elevation of the structures;
   - iii) all significant areas of deterioration on the upper and lower deck surfaces and in the various bridge components (use of a telephoto lens may be necessary); and
   - iv) each deck joint

13) Repair all core holes with Ministry approved repair material[1]. The sides of the core hole shall be cleaned and water shall be removed before concrete is placed.

14) A description shall be produced for each core which shall consist:
   - i) a dimensioned sketch;
   - ii) a colour photograph, taken in a studio environment, arranged to show deterioration or unusual features (cores may be grouped no more than three per frame); and
   - iii) completion of the Core Log Form for Exposed Concrete Bridge Decks.[1]

Cores shall be tested in accordance with the requirements of Table 1. For most decks, physical testing will not be required on many of the cores. All cores, and parts thereof, shall be retained for a period of six months after submission of the final report. Cores taken through curbs or sidewalks (as part of Item 9) shall be retained until notified by the Ministry.

Table 1/Requirements for Testing Cores

Test	Compressive Strength	Chloride Content	Air-Void System
No. of Specimens	Not Less than 1 nor more than 6*	Deck size No. $<500\,m^2$ 1 500 to $2000\,m^2$ 2 $>2000\,m^2$ 3	1
Test Method	CAN3-A23.2-14C (moist condition)	MTC**	ASTM C457
Laboratory Approval	C.S.A. or MTC	MTC	MTC
Other Requirements	Choose core without steel and with $L/D>1.0$	One core should be from near the curb.†	Only for decks built 1958 and later.

* The higher number will normally apply only to very large decks or decks in poor condition.

** Method of Testing for Water Soluble Chloride Ion in Concrete.

† Where significant deterioration exists on the deck soffit, the full length core shall be tested by measuring the chloride content in alternate 10 mm thick slices for the whole core.

15) The final report shall contain the following.
   i) Structure identification[1] including location, type, size and age.
   ii) Identification of the test equipment[1].
   iii) Four plans to a scale of 1:100 showing:
      a) spalled, patched, scaled and delaminated areas and significant cracks on the top surface of the deck, curbs and sidewalks;
      b) concrete cover measurements at grid points and the 20, 35 and 50 mm contours—areas between contour lines shall be shaded and the values shown on the Survey Summary Sheet;
      c) half cell potentials grid points (and intermediate points where taken) and the −0.20 V, −0.35 V, −0.45 V and −0.55 V contours—areas between contour lines shall be shaded and the values shown on the Survey Summary Sheet[1]; and
      d) the condition of the bottom surface of the deck slab and, where present, the location of void drains shall be shown. (Where there is very little deterioration on both the top and bottom of the deck, and the information can be shown clearly, plan (d) may be combined with plan (a).

      A key plan showing the location of the structure shall be shown on at least one plan and the position of all cores and deck drains shall be shown on all four plans. Pencil drawings and freehand lettering are acceptable providing they are neat and clear.
   iv) A Survey Summary Sheet[1].
   v) The photographs specified in Section 12. A colour print is required in each copy of the report.
   vi) A core log,[1] sketch and photograph for each core.
   vii) A written summary of the significant findings.
   viii) The stamp of the Engineer responsible for the work.

B)/For Asphalt-Covered Concrete Deck Slabs

1) Determine the general condition of the bituminous overlay and record significant cracks (greater than 3 mm wide) in the wearing course. Cracks which have been sealed shall be so noted.

2) Record and measure (size and location) patched and open spalls on the curbs and sidewalks. Determine and measure delaminated areas on the curbs and sidewalks using a chain drag or similar technique. Record and measure scaled areas on curbs and sidewalks, and classify by visual assessment to the degree of severity according to the scale given in Part A, Item 3.

3) Determine the corrosion activity of the top mat of reinforcing steel using a copper-copper sulphate half cell survey based on a 3 m square grid of the deck surface. The test method shall be ASTM C876. The deck shall be surface dry at the time of test. It is recommended that this test not be performed at temperatures less than 10°C and shall not be carried out unless the air and deck temperature is at least 5°C. Deck temperature shall be measured at the interface between the asphalt and the concrete deck slab. Where the difference in potential between adjacent grid points is 0.15 V or greater, the potential halfway between the grid points shall be recorded. The procedure shall be repeated until readings between adjacent points do not exceed 0.15 V (except within 1 m of a joint). All readings shall be taken on grid lines. Contact with the concrete surface shall be made by drilling 15 mm diameter holes through the asphalt and waterproofing layer (where present). It is not intended that the hole penetrate the deck slab. Drilling dust shall be removed before wetting solution is placed in the hole.

   The following information shall be recorded:
   i) the temperature and time when the test is begun and completed;
   ii) the location and method of connection to ground[2]—a separate ground connection is required wherever the deck slab is not structurally continuous;
   iii) the method of checking and the value of resistance of ground connection;
   iv) the thickness of the asphalt at each grid point (in the 15 mm diameter holes); and
   v) concrete cover at ground rebar locations.

4) Take cores to determine the thickness of the asphalt surfacing, the general condition of the concrete, the nature of defects and to obtain specimens for laboratory testing. It is expected that the cores will be representative of the condition of the concrete in the deck slab and will include cores taken in areas of deterioration or suspected deterioration (including cracks, wet spots on the deck underside and areas of high potential). A chain drag survey is often useful in indicating areas of suspected deterioration, though the results of such a survey should not be reported. It is further expected that the cores will be taken from widely separated locations on the deck surface. The cores shall be 100 mm diameter. Where it is difficult to remove the cores, the drilling of a 150 mm core through the asphalt and a 100 mm in the concrete is acceptable. One of the cores shall be taken the full depth of the deck slab (except for thick slabs); the remainder shall be long enough to carry out the required tests. Cores are not to be taken within the sawn sample areas except where a core without reinforcement (for testing for compressive strength)

cannot otherwise be secured. In this case a pachometer may be used to locate the steel in the sawn sample area. Cores shall not be taken through prestressing steel. The number of cores shall be not less than 1 nor more than 3 per 100 m^2 of deck area with a minimum of 6 per structure. It is expected that the number of cores taken from decks in poor condition will approach the maximum with the majority taken in areas of deterioration.

5) Selectively remove the bituminous surfacing by dry-sawing to determine the condition of the concrete slab and the cover to the reinforcing steel. The minimum size of each removed sections shall be 250 mm x 250 mm and the number of removed sections shall be not less than 1 nor more than 3 per 200 m^2 of deck surface with a minimum of 3 per structure. The majority of samples shall be in areas of suspected deterioration and at least one shall be adjacent to the curb. Record the cover to the top layer steel in each removed area using a pachometer.

6) Determine the condition, type and thickness of the waterproofing membrane (where present) from the cores and sawn samples.

7) When specifically requested by the Ministry, one core shall be taken at one end of the structure near the centreline of the highway and approximately 3 m from the deck joint to establish whether a concrete approach slab is present. The thickness of the asphalt and concrete (if present) shall be reported. No testing is required on this core.

8) Where it is known that rehabilitation will involve removal of a curb or sidewalk, at least two cores shall be taken from each side of the bridge to establish the quality of the bond with the deck slab. Cores shall not be taken through utility ducts. No physical testing is required on these cores. The cores shall only be taken when specifically requested by the Ministry.

9) Inspect and record defects on the underside of the deck surface, including significant cracks, spalling, wet spots, leaching, honeycombing, and exposed reinforcement. Where warranted by the degree of deterioration, the work shall be performed from a boat bucket truck or other appropriate means of access to the deck soffit. The location of void drains shall be noted.

10) Complete the Component Inspection Form.[1] The following information shall be recorded:

   i) joint type, and measurement of length, curb height, width, gap, and temperature at the time of measurement—where the joint has been paved over, the surfacing shall be removed at each curb and at the centreline of the highway to record the appropriate measurements;

   ii) deck drain size, number, location and condition—the length and inclination of the pipes to the vertical shall be estimated and recorded;

   iii) bearing type, number, size and condition—where access is difficult, further instructions shall be sought from the Ministry; and

   iv) condition of beams, barrier walls, handrail posts, bridge approaches, abutments, ballast walls, slope protection and other components appropriate to future repair and rehabilitation programs.

   It is the intent that the condition of components other than the deck will be assessed and recorded only in so far as future rehabilitation is affected. Physical testing of these components is not required.

11) Colour photographs shall be taken of:

   i) a general view of the deck surface;

   ii) a side elevation of the structure;

   iii) all significant areas of deterioration on the upper and lower deck surfaces and in the various bridge components (use of a telephoto lens may be necessary);

   iv) the deck surface in the sawn sample areas; and

   v) each deck joint.

12) Repair all drill holes by removing the wetting solution and caulking with Bituthene mastic for the full depth of the hole. Sprinkle fine sandon the surface to prevent tracking.

13) Repair all core holes with a Ministry-approved repair material[3] placed to the level of the concrete deck surface. The sides of the core hole shall be cleaned and water shall be removed before concrete is placed. On decks which are waterproofed, a disc of Bituthene HDG shall be placed on the concrete. Cold-mix asphalt shall then be compacted to be slightly above the level of the bituminous surfacing.

14) Repair all sawn sample areas with cold-mix asphalt compacted to be slightly above the level of the bituminous surfacing. On decks which are waterproofed a piece of Bituthene HDG shall be cut to fit the removed area. Bituthene mastic shall be applied over the bottom surface of the membrane and the membrane shall be placed on the concrete deck surface before placing the cold-mix asphalt.

15) A description shall be produced for each core which shall consist of:

   i) a dimensioned sketch;

ARTICLE 2/ SERVICES (Continued)

- ii) a colour photograph, taken in a studio environment, arranged to show deterioration or unusual features (cores may be grouped no more than 3 to a frame); and
- iii) completion of the Core Log Form for Asphalt-Covered Bridge Decks[1].

Cores shall be tested in accordance with the requirements of Table 1. For most decks, physical testing will not be required on many of the cores. All cores, and parts thereof, shall be retained for a period of six months after submission of the final report. Cores taken through curbs or sidewalks (as part of Item 8) shall be retained until notified by the Ministry.

16) A description shall be produced for each sawn sample which shall consist of:
- i) the photograph of the concrete deck surface; and
- ii) Completion of the Sawn Asphalt Sample Log Form[1].

No physical testing is required and the samples need not be retained.

17) The final report shall contain the following.
- i) Structure identification[1] including location, type, size and age.
- ii) Identification of the test equipment used[1].
- iii) Three plans to a scale of 1:100 showing:
  - a) significant cracks in the bituminous surfacing and spalled, patched, scaled and delaminated areas on the top surface of the curbs and sidewalks;
  - b) the condition of the bottom surface of the deck slab, where present, the location of the void drains shall be shown; and
  - c) half cell potentials at grid points (and intermediate points where taken) and the −0.20 V, −0.35 V, −0.45 V and −0.55 V contours—areas between the contour lines shall be shaded and the values shown on the Survey Summary Sheet.

  A key plan showing the location of the structure shall be shown on at least one plan and the position of all cores, sawn samples and deck drains shall be shown on all three plans. Pencil drawings and freehand lettering are acceptable providing they are neat and clear.
- iv) A Survey Sheet[1].
- v) The photographs specified in Section 11. A colour print is required in each copy of the report.
- vi) A core log[1] sketch and photograph for each core.
- vii) A sawn sample log[1] and photograph for each sample.
- viii) A written summary of the significant findings.
- ix) The stamp of the Engineer responsible for the work.

2.2/ Traffic Control Measures

When requested, the Consultant's services shall include the provision of flagmen, temporary traffic signals, signs and other devices specified for the control of traffic and lane closure on the bridge deck and adjacent portions of the highway.

2.3/ Ministry's Services

The Ministry shall provide the following:

1) Designation of the concrete bridge decks to be inspected (Appendix A of the Agreement).
2) Provision of copies of the original design drawings for the deck slabs.
3) Copies of previous inspection reports.
4) Designation of the Consultant's working hours.
5) Designation of the traffic control arrangements.

FOOTNOTES TO APPENDIX A

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[1] Standard forms are available from the Engineering Materials Office and the Regional Structural Sections of the Ministry.

[2] The following methods are acceptable: self-trapping screw, compression-type clamp, brazing or welding. Adhesive tape is not acceptable.

[3] A list of approved repair materials can be obtained from the Engineering Materials Office of the Ministry.

APPENDIX B/ PROTECTIVE TREATMENTS FOR BRIDGE DECKS IN ONTARIO

The purpose of this Appendix is to summarize the type of protective treatments which have been used in Ontario. Changes in standards have resulted in some structures being prone to certain types of deterioration. Consequently, there is often a relationship between the age of a structure and its condition. The common defects are described in detail in Section 2.

It should be noted that deck slabs are normally stripped and repaved when the adjacent highway is resurfaced (typically every 15 years). Waterproofing therefore may have been added or replaced as part of the repaving contract. Occasionally, highways have been resurfaced by paving over the deck slabs (without stripping) and a considerable thickness of asphalt on older decks is not uncommon.

Because the time between design and construction varies, there is some overlap between the date and the construction methods given below.

1. Constructed Prior to 1958

The deck slabs were not waterproofed at the time of construction.

The concrete was not air-entrained. These decks are prone to salt penetration and to severe scaling due to freeze-thaw action.

The condition of these older deck slabs varies considerably.

2. Constructed Between 1958 and 1961

The concrete was specified to be air-entrained but the admixtures used did not produce a good air-void system and the control of air content was poor. Many deck slabs were treated with silicone prior to the paving but this was not effective in preventing salt penetration. These decks are also prone to salt penetration and to scaling but their condition is generally better than pre-1958 structures.

3. Constructed Between 1962 and 1964

Deck slabs waterproofed using mastic asphalt or glass fibre in an asphalt emulsion. Most membranes were ineffective after a few years in service. The concrete was air-entrained but the control on air content was not good. The condition of the decks is variable, but is generally fair to good.

4. Constructed Between 1965 and 1972

The decks were built with exposed concrete wearing surface and minimum cover to reinforcing steel was specified to be 40 mm, but the cover requirement was generally not met. Most decks exhibit corrosion-induced distress. The concrete was generally properly air-entrained and of good quality. Many of these decks have now been waterproofed and paved.

5. Constructed 1973 to 1978

The deck slabs were waterproofed with a rubberized asphalt waterproofing membrane. Mastic asphalt was used on some rigid frames throughout the period and also on other types of structures until about 1976. A protection board was used with rubberized asphalt after 1975. Most decks are in good condition.

6. Constructed After 1978

The decks contain epoxy coated reinforcing bars as the top mat of steel and are waterproofed with rubberized asphalt membrane and protection board. Specified cover is 70 ± 20 mm. The decks are in good condition.

APPENDIX C/ EQUIPMENT LIST

The purpose of this Appendix is to provide a list of equipment and tools required to carry out a condition survey. It is intended that the list will provide some guidance as to the type and variety of equipment required. Vehicles required to transport equipment and personnel are not included. The equipment list is divided into three categories:

- exposed concrete decks and asphalt-covered decks;
- asphalt-covered decks only; and
- assorted tools required for all surveys.

In many cases the sawing and coring is done by a subcontractor who specializes in that type of work, not by the survey crew.

Exposed Concrete and Asphalt-Covered Decks

- Gasoline powered electric generator capable of providing power simultaneously to a core drill, portable drill, and a hammer breaker/compactor.
- Extension cords.
- Electric core drill with 100 mm and 150 mm bits, core retrievers, water tank and necessary hoses to supply water to core drill.
- Portable breaker/compactor and attachments.
- Portable electric drill with suitable carbide bits.
- Voltmeter and suitable lead wire as specified in ASTM C876.
- Copper-copper sulphate half cell as specified in ASTM C876.
- Pachometer (or Covermeter).

Asphalt-Covered Deck

- Self-propelled gasoline powered saw, suitable for dry sawing asphalt complete with 400 mm blades.
- Spray can suitable for applying wetting solution.
- Caulking gun and Bituthene caulking material for filling holes drilled in asphalt for half cell testing.
- Cold mix and Bituthene HDG waterproofing material for repairing core holes and sawn sample areas.

Assorted Tools and Materials

- camera and film;
- binoculars;
- measuring tapes—30 m and 5 m;
- heavy logging chain, typically 2 m long;
- blank forms;
- field books and scratch pads;
- field grid sheets;
- pens, pencils, pencil sharpeners and erasers;
- yellow marking crayons;
- canvas sample bags;
- a number of pieces of 13 mm plywood with wire attached, suitable for using as forms when filling full depth core holes;
- Ministry approved concrete repair material for filling core holes;
- rubber pails;
- thermometers for measuring air and concrete temperatures;
- personal safety equipment such as hard hats, safety shoes, safety vests, goggles, work gloves etc.;
- sponges and rags;
- string and tape; and
- traffic control items such as signs, delineators (cones) and flags.

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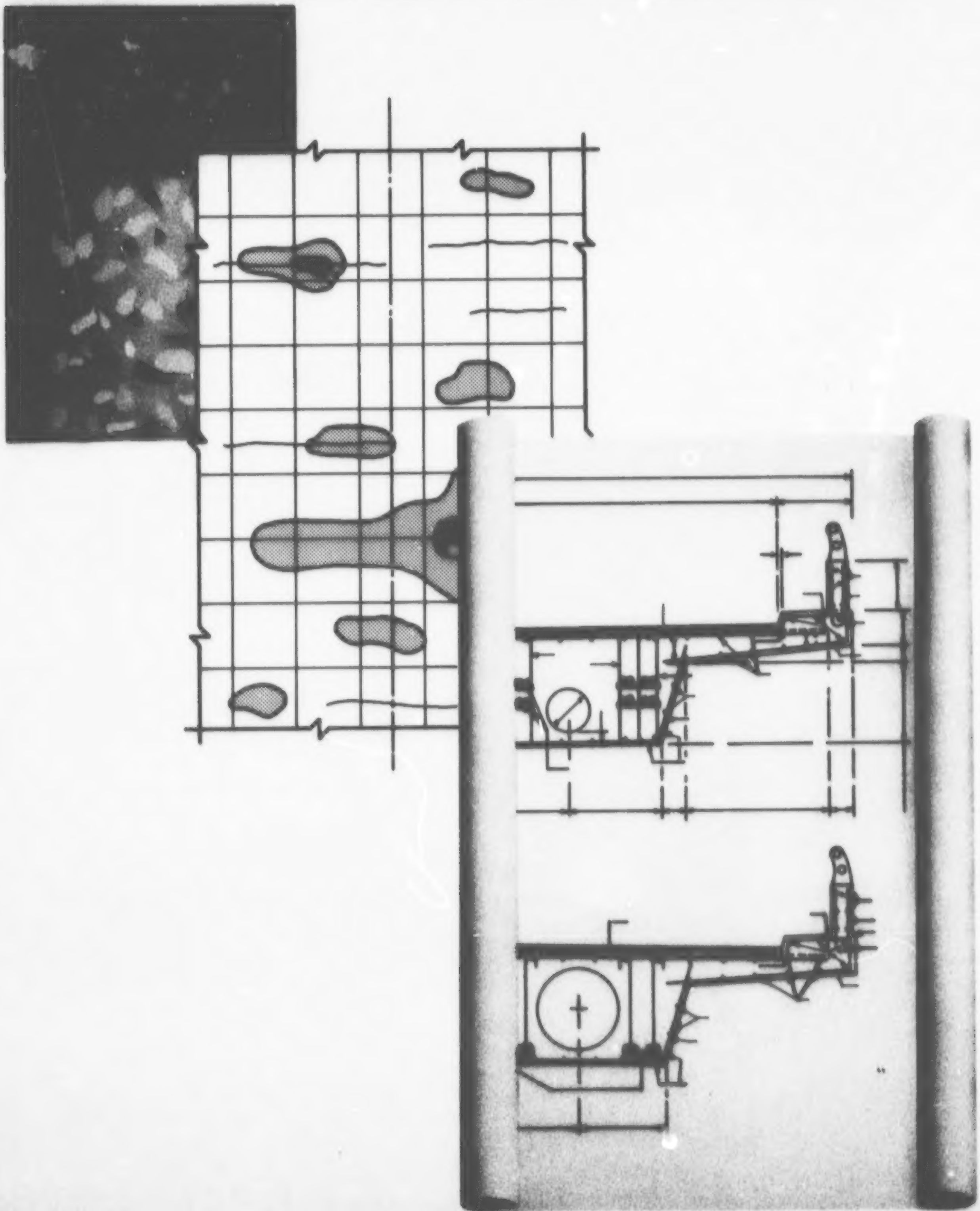
Ontario

Ministry of
Transportation and
Communications

Research and
Development
Branch

Bridge Deck Rehabilitation Manual

Part Two: Contract Preparation



Bridge Deck Rehabilitation Manual

Part Two: Contract Preparation

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1/ INTRODUCTION

1.1/ Scope and Purpose

The overall scope and purpose of Parts One and Two of the manual and its supplement were described in the introduction to Part One.

Part Two covers the planning and design of a rehabilitation contract. It shows how the information collected in the detailed condition survey described in Part One is used to select the method of rehabilitation and to prepare the contract documents.

The manual has been written to conform to Ministry practice. The detailed condition survey is normally carried out by consultants but no recommendations for repair are required and the decision on the method of rehabilitation is made in-house. The contract documents may be prepared in-house or by a consultant. Other authorities, especially municipalities, frequently engage consultants to carry out the condition survey, make recommendations for repair, prepare the contract documents and supervise the construction. Occasionally all the activities may be carried out by one consultant but frequently two or more consultants will be involved. Where this manual is used by other authorities, the scope of the work needs to be clearly defined in the agreement with each consultant.

Section 2 details the processes involved in review and analysis of the data leading to the identification of the repair method. Three options of rehabilitation are discussed; concrete overlay, cathodic protection, and patch, waterproof and pave. Considerations for including repairs to other components in the structure in the contract for the rehabilitation of the deck are also described. However, the repair of substantial areas of deterioration to such components as piers, abutments and beams is outside the scope of this manual since insufficient data is collected in the bridge deck condition survey to prepare the necessary contract documents. In such cases, a detailed condition survey of the affected components would be required.

Section 3 summarizes the essential construction procedures used for each of the rehabilitation methods included in the manual. Because of the greater complexity of the design process, cathodic protection is treated in greater detail than are the other methods of rehabilitation. The section has been written for the user who is not familiar with these rehabilitation methods. It is expected that the more experienced user will utilize the contents of Sections 2 and 4 in preparing a rehabilitation contract, using Section 3 for reference purposes only.

Section 4 describes the preparation of the contract documents. Most of the activities likely to be encountered in rehabilitation contracts have been covered. Only some of these activities will be included in any one contract. Consequently, considerable care is required in ascertaining that specific items are appropriate to the job in hand. Sample special provisions and reference contracts which can be used as a guide in preparing contract documents are contained in the Supplement to the manual.

2/ PLANNING AND DESIGN

2.1/ Introduction

Deck rehabilitation may be carried out as a separate contract or as part of a larger contract which includes other types of work such as grading and paving. In either case, the structure component of the contract is the responsibility of the staff of the Regional Structural Section (the person responsible is referred to as the Project Engineer throughout this manual). Where the contract includes mainly work on structures, the same person may also be the Project Manager responsible for assembling the entire contract package.

The contract documents for deck rehabilitation will be prepared in-house (i.e., within the Regional Structural Section) or by a consultant. The "consultant" may be the Ministry's Structural Office or a firm from the private sector. This manual is concerned only with the preparation of those documents and includes the activities performed by the Regional Structural Section and, where applicable, the consultant.

2.2/ Review of Data

Before establishing the method of rehabilitation, the Project Engineer must be familiar with the following:

- bridge deck condition survey,
- existing structure drawings,
- maintenance inspection file,
- site conditions (topography and traffic volumes),
- Bridge Deck Rehabilitation Manual,
- future plans for the highway, and
- other proposed contracts in the vicinity (Ministry or Municipality).

The more important items of information from the above are listed in Sections 2.2.1 to 2.2.4.

2.2.1/ Bridge Deck Condition Survey

- type, extent and location of deterioration
- concrete cover (affects scarifying)
- core test results
- depth of asphalt
- presence of waterproofing
- joint details
- site topography
- components which require upgrading (e.g., handrails, parapet walls)

2.2.2/ Existing Structure Drawings

- structure type and size
- unusual design features
- roadway widths (for staging)
- curb heights
- joint details including anchorage
- utility ducts

2.2.3/ Maintenance Inspection File

- history of deterioration
- previous repairs (including epoxy injection) and resurfacing
- deterioration in other components of the structure

2.2.4/ Site Conditions

The Project Engineer should visit the site to familiarize himself with the following:

- traffic conditions;
- geometry of adjacent highway;
- options for staging (including detours);
- accessibility of components in need of repair;
- nature and extent of deterioration;
- deviations from design information;
- any unusual features, e.g., utilities, drainage; and
- need for liaison with other authorities.

2.3/ Options for Deck Rehabilitation

The options for repair covered by this manual are:

i) Patch, waterproof and pave
ii) Concrete overlay — normal-slump concrete
— low-slump concrete
— latex-modified concrete
iii) Cathodic protection

The important features and method of construction of each of these methods are described in Section 3.

2.4/ Selection of Rehabilitation Method

The selection of the repair method is the crucial step in deck rehabilitation. It is often a difficult process which involves consideration of a large number of factors, some of which are technical, some economic, and others which are purely practical.

Although structural analysis is outside the scope of this manual, deck rehabilitation cannot be separated from an evaluation of the load-carrying capacity of the structure. The first step in preparing any rehabilitation contract is to ensure that the completed structure will be structurally adequate. This means that the deck can, in fact, be repaired (as opposed to replaced) and that all elements of the structure will support any additional loading resulting from the rehabilitation.

The following guidelines should be used to determine when deck replacement is warranted:

- The deck has deteriorated such that it cannot be repaired. The most common examples are in older decks where the concrete has suffered from alkali-aggregate reactivity or freeze-thaw damage through the full depth of the slab.
- The cost of repairs is a significant proportion (often taken as 50%) of the cost of replacement. However, the final decision should be based on a complete financial analysis and assessment.
- The slab is structurally deficient or the structure will not support the necessary additional dead load.

Where the structure is found to be functionally obsolete when current criteria for width, clearance, alignment and load limits are applied, or where deficiencies are present in elements of the structure which will limit its service life, then the deck rehabilitation strategy must be compatible with the life of the structure as a whole. In other words, a deck rehabilitation scheme with an anticipated service life of 15 years would not normally be carried out on a structure scheduled for replacement or widening within 10 years. In such cases a financial analysis and assessment should be made of the various repair and replacement options.

The factors which most influence selection of the rehabilitation method are:

- the location of the structure and its importance in the highway network;
- the volume of traffic at the site and the impact of lane closures on traffic flow;
- the type of structure, its size and geometry;
- the nature of the deterioration;
- the extent of the deterioration;
- the anticipated remaining service life of the structure;
- the load-carrying capacity of the structure;
- the cost of repairs and availability of funds;
- the future reconstruction program; and
- local experience and contractor expertise.

Table 1/ Relative Merits of Rehabilitation Methods

Rehabilitation Method	Advantages	Disadvantages
Concrete overlay	Structural component of deck slab. Relatively impermeable. Relatively long service-life. Well-suited to repair of badly spalled or scaled decks. Increases cover to reinforcing steel. Many qualified contractors.	Less suited to decks with complex geometry. Cannot bridge active cracks. Difficult to provide adequate texture on low-slump concrete surface. May not stop active corrosion.
Waterproofing membrane with bituminous concrete wearing course	Bridges active cracks. Relatively impermeable. Provides good riding surface. Applicable to any deck geometry. Many qualified contractors.	Performance highly variable. Will not stop active corrosion. Not suited to rough deck surfaces. Service-life limited by wearing course. Non-structural component of deck slab. Not recommended for grades in excess of 4% where heavy vehicles make turning or braking manoeuvres.
Cathodic protection	Stops active corrosion. Can be used on decks with active cracks. Provides good riding surface. Applicable to any deck geometry.	Presence of wearing course without waterproofing may accelerate deterioration of the concrete. Non-structural component of the deck slab. Periodic monitoring required. Service-life limited by wearing course. Specialized contractor and inspection required. Electrical power source required.

The importance of the structure is determined by traffic volumes at the site and the availability of alternative routes. Consequently, some structures, particularly those on urban freeways where lane closures cause a serious disruption to traffic flow, may warrant selection of a combination of protective treatments (even though this may involve additional costs) in order to maximize service life. Traffic volumes also influence the choice of repair method in that they determine the number of lanes which can be closed at any one time and the length of time for which they can be closed.

Some types of structure present particular difficulties. For example, structures where the deck is an integral part of the superstructure (as is the case with thick slab decks and some box and tee girder bridges), are more sensitive to deterioration and may also warrant additional treatments to ensure a durable repair. The size of the structure influences the economics of the various rehabilitation strategies and unusual deck geometry may eliminate some options.

Table 2/ Decision Matrix for Selection of Deck Rehabilitation Method

Criterion	Concrete overlay	Waterproofing membrane and paving	Cathodic protection	Rationale
Delamination and spalls exceeding 10% of the deck area.		No	No	Where extensive patching is required it becomes more economical and more durable to construct a concrete overlay.
Corrosion potential more negative than −0.35 V over more than 20% of the deck area.		No		Patch repairs and waterproofing rarely reduce corrosion activity and may accelerate it.
Moderate or heavy scaling exceeding 10% of the deck area		No	No	The amount of patching becomes too expensive and consequently uneconomical.
Active cracks in deck slab.	No			Cracks active under live load or temperature change are reflected in a concrete overlay.
Remaining life of structure less than 10 years.	No		No	Additional cost of a concrete overlay or cathodic protection is not justified.
Concrete not properly air entrained.			No	Application of a bituminous surfacing (without waterproofing) may accelerate deterioration of the concrete.
Complex deck geometry. Skew exceeding 45°, curvature exceeding 10°, or changing super-elevation.	No			Concrete finishing machines (especially those used for low-slump concrete) have difficulty accommodating complex geometry.
Limited load capacity of structure*		No	No	Bituminous overlay is a non-structural component. Concrete overlay can be especially useful where the span/thickness ratio of deck slab exceeds 15.**
Electrical power unavailable.			No	Power required for rectifier (unless mains, solar, wind or battery power can be provided economically.
Epoxy injection repairs previously performed and will not be removed.			No	Epoxy insulates underlying reinforcement from cathodic protection.

* Capacity after rehabilitation must be verified. Additional strengthening may be necessary.

** See OHBDC Section 7.

The future construction program has a major influence on the timing of repairs, but it can also influence the selection of the rehabilitation method. Where realignment or geometric improvements to the highway are anticipated, a minimum amount of work will be done sufficient to maintain the structure in service until the future improvements are carried out. Conversely, rather than award a separate contract at a later date, it may be more economical to include nearby structures in a contract, even if they do not warrant immediate rehabilitation. An attempt will normally be made to ensure that the rehabilitation scheme is compatible with other activities in the contract, or a separate contract will be prepared. Consideration must also be given to the expertise of local contractors and available construction equipment, especially on small contracts where the costs of mobilizing a specialized contractor from outside the area would be prohibitive.

The technical considerations in selecting the method of rehabilitation can conveniently be dealt with by examining the relative advantages and disadvantages of the repair options as shown in Table 1. A decision matrix (given in Table 2) has been developed which quantifies the information contained in Table 1 and this can be used to select the method of rehabilitation. The rationale used to develop the matrix is also contained in Table 2.

Tables 1 and 2 do not differentiate between the three types of concrete overlay available (latex-modified, low-slump, and normal-slump concrete). The following guidelines govern their use. Normal-slump concrete overlays are rarely used as the exposed deck surface because they are more permeable than either low-slump or latex-modified concrete overlays. The most common application is in combination with waterproofing and paving on asphalt-covered decks which are badly deteriorated. The specified thickness is 50 mm or more. For an exposed concrete overlay, either 50 mm of low-slump or 40 mm of latex-modified concrete may be specified. In order to promote competitive bidding, the two types of concrete overlay (low-slump and latex-modified) can be included in the same contract as a contractor's option. There are situations, however, where only the latex-modified concrete overlay is suitable. This occurs, for example, where it is necessary to minimize dead load or where the geometry of the deck is so complex that the required profile cannot be placed by the low-slump finishing machine. This machine has a transverse screed which cannot accommodate a change in crown.

It should be noted that the decision matrix in Table 2 is constructed such that it leads, by elimination, to the selection of the rehabilitation scheme which has the fewest disadvantages. In some cases the matrix may exclude all the repair methods – as, for example, a deck with active cracks (cracks which move in response to loading or changes in temperature or humidity) and with spalls and delamination over more than 10% of the deck area. In this case, it is necessary to work through the matrix again and, on the basis of engineering judgement, examine the implications of violating each criterion in turn. In the example quoted, the choice may be between paying the high cost of patching the deck prior to applying cathodic protection and accepting the risk of reduced service-life as a result of cracking in a concrete overlay.

The criteria contained in Table 2 cannot be rigid because of the complexity of the decision-making process, but the figures are a useful starting point and they are applicable to most structures. In extreme cases, but only where necessary, it could be advantageous to combine the various systems to optimize the rehabilitation scheme. In the example quoted above it may be desirable to apply a concrete overlay followed by either waterproofing and paving or cathodic protection, especially if the structure is classified as important. It is clear from the above that while guidelines can be established for the selection of the rehabilitation method, these are not absolute and there can be no substitute for good engineering judgement.

The guidelines deal with the technical and practical considerations in selecting the rehabilitation method exclusive of costs. Although of paramount importance, costs have been found to vary so widely with deck size and location that it is difficult to generalize. Furthermore, because of work which is included in a rehabilitation contract and independent of the repair method (e.g., joint modification, traffic control, and repairs to other components), the total contract cost may be relatively insensitive to the cost of the deck treatment (which is typically 30 to 50% of the total cost). The costs of cathodic protection and concrete overlay are comparable. The costs of patching, waterproofing and paving are strongly dependent upon the amount of patching required but tend to be somewhat lower than the costs of a concrete overlay or cathodic protection. An accurate cost comparison of the various repair options available can only be made for the particular site under study using the most recent cost information available.

2.5/ Component Repairs

It is necessary to determine which components should be included in the deck rehabilitation contract and to decide whether the component should be replaced, upgraded, or repaired. Where substantial repairs are required to the substructure, consideration should be given to awarding the work in a separate contract. Some of the more common examples of the upgrading or repairs to components are given in Sections 2.5.1 to 2.5.7.

2.5.1/ Deck Drains and Drainage Tubes

Consideration should be given to replacing drains in poor condition or less than 150 mm diameter. However, there are some situations where a large number of small-diameter drains are functioning properly and replacement is not warranted. Deck drains on exposed concrete decks will require an extension upward to match the new surface elevation. Deck drains discharging on beams, piers, or other components should be extended downward or have the point of discharge diverted.

The drainage tubes installed to drain moisture accumulating beneath the asphalt may also cause deterioration by discharging on beams or even inside box girders. Where such conditions exist, the tubes should be diverted, extended or replaced. New drainage tubes should be installed where none exist. This is especially important where a cathodic protection system is used because there is no waterproofing membrane. On waterproofing contracts it is necessary to ensure the drainage tubes are not blocked.

2.5.2/ Bearings

With the exception of jacking a structure to restore a bearing to its neutral position, or the cleaning and lubrication of steel rockers or rollers, there are few maintenance procedures for bearings. Defective, corroded or frozen bearings are normally replaced by a bearing of modern design.

2.5.3/ Handrails, Parapet and Barrier Walls

Deteriorated areas of concrete parapet and barrier walls will normally be repaired. Consideration should be given to replacing handrails (and parapet walls in poor condition) with barrier walls having a safety profile, especially on roads with high traffic volumes. If not replaced, broken sections of steel or aluminum handrail should be repaired. This work may be more suited to maintenance forces than to inclusion in a rehabilitation contract.

2.5.4/ Curbs and Sidewalks

Deteriorated areas should be repaired. Curbs should be removed if handrails are replaced with barrier walls.

2.5.5/ Joints

Joints which are defective, including those which are leaking, should be repaired or replaced by a joint which is suitable and listed on the Ministry's Designated Sources List, DS 141. Where possible, the existing anchorage should be utilized. However, care must be taken to ensure that the alignment of the top of the joint across the width of the deck is compatible with the proposed elevation of the deck surface. It is rarely practical to insert shims of different thicknesses. Where the existing joint cannot be modified, a new joint assembly and end dams should be constructed in accordance with current Ministry standards. Mechanical friction-type anchor bolts or anchor bolts embedded in a sleeve of grout have been found unsatisfactory and should not be used in trafficked areas.

Styrofoam which has been left between the ballast wall and the bridge superstructure, should be removed since it traps moisture and accelerates deterioration of the concrete.

2.5.6/ Beams, Piers and Abutments

Deteriorated areas should be repaired.

2.5.7/ Ballast Walls and Approach Slabs

Ballast walls which are extensively deteriorated or damaged by movement of the structure, abutment or adjacent pavement will normally require replacement. A lesser degree of deterioration can normally be repaired. Where the ballast wall is replaced a portion of the approach slab or pavement will also have to be replaced.

2.6/ Traffic Control and Protection

The method of traffic control and protection of construction personnel must be decided from the following options or combinations:

Traffic Control

- detour
- signing and lane closures
- temporary signals
- flagging

Traffic Protection

- construction markers
- temporary concrete barriers
- temporary steel beam guide rail

Where a convenient detour exists, it is often advantageous to close a bridge to traffic during repair because this allows the contractor to operate with maximum efficiency. Consequently, this is the most economical solution and the time that traffic is disrupted is kept to a minimum. Where closures are being considered it is essential that emergency services and local authorities be advised early in the planning stage. However, the opportunity to detour traffic is rarely available and most rehabilitation contracts are carried out in stages.

Concern has frequently been expressed about the effect of traffic-induced vibrations on the fresh concrete in bridge deck overlays and widenings. This concern focuses on the fact that the vibrations may cause an uneven riding surface or induce cracks and impair bond of the concrete, thereby reducing the service life of the rehabilitation. There is, however, substantial evidence that the quality of the construction is not adversely affected when traffic is maintained on a structure undergoing repair provided that good concreting practices are followed. Consequently, the elimination of vibrations is not sufficient reason to close a bridge to traffic to carry out rehabilitation. It is prudent, however, to minimize the effects of traffic-induced vibrations. Since these vibrations result from the excitation of vehicles by irregularities such as spalls and joints in the pavement, maintaining a smooth approach pavement and a smooth transition at expansion joints by providing temporary patches and ramps are more effective in reducing the amplitude of traffic-induced vibrations than speed and weight restrictions.

There is a very close relationship between the lane closures and the construction staging. On two-lane highways few problems are encountered. The work is normally done in two stages by closing one lane at a time while maintaining traffic in the other lane. This results in a longitudinal joint at the crown line, which is the preferred location for a construction joint.

On bridges with more than two lanes of traffic, particularly those on freeways, the situation can be much more complex. The requirements for design and construction are that the number of stages be kept to a minimum. It is also important to avoid a longitudinal joint in either a concrete overlay or a bituminous surfacing which coincides with a wheel track in the finished pavement. On structures with complex geometry, staging may be dictated by the position of the crown line, depending upon the method of rehabilitation selected.

The requirements for traffic control are to provide safe passage through the construction zone while keeping the disruption of traffic flow to a minimum. The number of lanes required and the need for speed restrictions will be determined by the Regional Traffic Section. Temporary lane widths will not normally be less than 3.35 m. The traffic control plan for construction staging and lane closures will be determined jointly by representatives from the Planning and Design, Traffic, and Structural Sections of the Regional Office. The Construction Office should be invited to review staging plans early in the design stage. In formulating the plan, analysis of the structure may be necessary to ensure that the proposed staging is feasible. This is most commonly required when a portion of the structure is removed or when the shoulder area is used as a traffic lane thereby resulting in either a reduction in load-carrying capacity or an unbalanced loading for which the structure may not have been designed. It is essential that the traffic control plan be finalized before detailed design work begins.

The Traffic Section makes the decision on whether signing, flagging, or temporary signals are required, on the basis of traffic volumes and the geometry at the site. In all cases, traffic control measures must conform to the requirements of the Traffic Control Manual for Roadway Work Operations. Once the traffic control plan has been formulated, the Project Engineer should prepare a schedule for informing all interested parties including emergency services and the media.

Protection needs to be provided for the travelling public and construction personnel. The decision whether to use delineators, temporary concrete barriers or steel beam guide rail is made by the Traffic Section and the Regional Construction Office on the basis of site conditions and the volume and speed of traffic. The usage of temporary steel beam guide rail attached to metal drums has declined in recent years with the introduction of the temporary concrete barriers. The steel beam guide rail is generally only used in locations where the concrete barrier units are not available. The temporary concrete barriers offer more protection than the steel beam guide rail and considerably greater protection than delineators. Temporary concrete barriers are supplied in 4 m lengths which are fastened together to form a continuous barrier. Special sections are used for the end treatment at the approaches. The barriers are reused and, in most cases, the cost is a relatively small part of the total cost of the rehabilitation contract.

2.7/ Engineering Survey

An engineering survey is normally carried out to determine existing alignment, profile and cross-section. It is especially important that such a survey be performed where the drainage is poor or the geometrics are unusual or deficient.

The data are used to:

- specify finished elevations to ensure adequate drainage (existing deficiencies can often be eliminated);
- calculate extensions to the top of drainage pipes;
- specify joint elevations;
- improve vertical alignment;
- identify where the approach pavement needs modifying;
- calculate screed elevations to ensure that the minimum thickness requirements for overlays are satisified;
- calculate quantities of materials; and
- identify the need for modifications to such items as curb height and guiderail height for reasons of safety.

The extent of the survey will vary with the site conditions and should be specified in the request from the Project Engineer to the Surveys and Plans Section.

Circumstances may exist, particularly on urban freeways, where it is not practical to carry out the engineering survey. In such cases, elevations will not be specified on the contract drawings and the responsibility for setting profiles in the field is assumed by staff of the Construction Office.

2.8/ Contract Preparation Scheduling

The time taken to prepare contract documents will inevitably vary with the complexity of a project and its priority. Table 3 provides a checklist of those activities which must be completed and indicates the approximate time required to complete each activity. As can be seen from Table 3, preparation of a bridge deck rehabilitation contract is a complex task, requiring input from numerous sources, and substantial time for assembly of the contract package. However, it should be noted that Table 3 has been compiled on the assumption that several projects are being done simultaneously by all the sections involved. Consequently, the time indicated in the "Time Required" column does not represent the actual time spent on the activity but allows for the activity to be incorporated into the work schedule of the section involved. The times given also allow for the activities to be carried out in the most efficient manner. For example, it is common practice to complete the field work portion of several condition surveys before writing the reports. If an authority were preparing a single rehabilitation contract, the contract preparation time would be expected to be considerably shorter than indicated in Table 3.

3/ BRIDGE DECK REHABILITATION METHODS

Table 3/ Contract Preparation Schedule

Activity	Responsibility	Time Required
Detailed Condition Survey	Structural Section In-House or Assigned to Consultant	Two to five months
Projected Assigned	Structural Section	
Establish Method of Rehabilitation	Structural Section (See Directive B118).	Four weeks
Design Criteria Approval	Project Manager	Four to six weeks
Engineering Survey	Surveys and Plans Section	Field–four weeks/site Plans–two weeks/site
Traffic Staging Recommendations	Traffic Section	Four weeks
Approach and Surface Treatment Recommendations	Geotechnical Section	Four weeks within the above
Bridge Site Plans (if required)	Surveys & Plans and Planning & Design Sections	Four weeks
Comment from External Agencies	Project Manager	Four weeks
Structural Planning Report	Structural Section	Four weeks
Structural Design and Drawings	Structural Section	Four to twelve weeks
Structural Documents	Structural Section	Four weeks
Grading Documents	Planning & Design Section	Four weeks within the above
Electrical Documents	Electrical Design	Four weeks within the above
Assemble Tender Documents	Project Manager	Four weeks
Submit Documents to Regional Contract Review Section	Project Manager	Two weeks
Technical Review	Project Manager	Two weeks
Resubmit to Regional Contract Review Section	Project Manager	Three weeks
Regional Review	Project Manager	Two weeks
Submit Documents to Contract Preparation and Control Section	Regional Contract Review Section	Three weeks
Review by Contract Management Office	Project Documents Review Unit	Four to six weeks
Preparation and Advertising	Contract Management Office	Eight weeks including above
Award	Contract Management Office	Five weeks

3.1/ Introduction

Section 3 describes the main features and the method of construction for the repair options covered in Section 2.

3.2/ Deck Preparation

The first steps in all rehabilitation work are the removal of any existing bituminous surfacing followed by the removal of deteriorated concrete and the preparation of a clean, sound surface. The work will include some or all of the following activities: scarifying, concrete removal and sandblasting. Where necessary, the first operation is to remove sand from winter maintenance operations and other debris from the deck using hand tools or a power sweeper.

3.2.1/ Scarifying

Decks are scarified prior to installation of a concrete overlay. The work involves removal of not less than 6 mm nor more than 10 mm of concrete from the entire deck surface. This is done to remove the surface concrete which may be contaminated by oil drippings and to produce a surface texture suitable for application of the overlay. Scarifying is done before chipping because many of the delaminations are removed by the scarifier. A mechanical scarifier consists of a large, self-propelled machine with a rotating drum with cutting teeth. Form 930 requires that the specified depth of concrete be removed in a single pass.

In areas of the deck where the reinforcing steel has little or no cover such that it would interfere with the scarifier, the concrete surface is prepared by hand chipping or scabbling.

In exceptional circumstances where additional dead load must be kept to a minimum, a greater depth of scarifying may be specified. However, care must be taken to ensure that the cover to the reinforcing steel is sufficient to allow the removal of the required thickness of concrete without damage to the reinforcement.

The scarified material is removed from the deck surface immediately after scarifying. If this is not done and the material becomes wet, the fine material adheres to the roughened surface and is very difficult to remove.

3.2.2/ Removal of Unsound Concrete

Delaminated and unsound concrete are removed using hand-operated power tools. In addition, any asphalt patches or areas of oil drippings or other contaminants must also be removed. The areas of concrete removal will be designated by the Engineer. This is normally done by sounding the deck with a heavy logging chain after scarifying and delineating the unsound areas using spray paint.

In the case of contracts involving the application of a waterproofing membrane or cathodic protection, the areas of concrete removal are "squared-off" and the perimeter of each patch is defined by a sawcut. The sawcut should be a minimum of 25 mm deep (except in areas where the concrete cover is less than 25 mm) to avoid feather-edging. It is good practice to tilt the saw blade to key-in the patch by making it wider at the bottom than at the deck surface. This can be done by running the wheels on one side of the saw on a board placed on the deck surface.

It is not necessary to sawcut around unsound areas prior to application of a concrete overlay because feather-edging will not occur and it is preferable to avoid sudden changes in overlay thickness.

Concrete above the level of the reinforcement is removed using jack hammers no larger than 14 kg. Chipping hammers no larger than 7 kg are used to remove concrete from around the reinforcement. Where it is necessary to chip below the bar a clear space of 25 mm must be provided. A useful test to ensure that the chipping is sufficient is to check that the bar can be gripped by the hand. Removal around the bars is necessary when any of the following conditions occur:

i) the bar is rusted heavily;
ii) more than one-half the perimeter of the bar is exposed;
iii) the bond to the bar is broken; or
iv) the concrete is unsound or honeycombed.

The above criteria should also be applied to determine the need for removing concrete around bars below the top layer. Concrete removal in the vicinity of cable or utility ducts or cable anchorages must be undertaken with great care.

The amount of concrete which should be removed is a contentious issue. Theoretically, all the concrete which contains chloride ions in excess of the threshold value for the corrosion of embedded steel should be removed to make a "permanent" repair. This would be prohibitively expensive. It is, therefore, current Ministry practice to remove only that concrete which is unsound or delaminated and accept the resulting reduction in the service life of the rehabilitation. However, it is prudent to remove concrete to below the level of the top steel from areas exhibiting high corrosion potentials (more negative than −0.35 V) where this can be done economically. These areas can be determined from the results of the half-cell survey contained in the condition survey report.

Debris from the chipping operation must be removed from the site and disposed of outside the right-of-way. Where large areas of reinforcing steel are exposed, the bars should be retied at each intersection point.

Occasionally, the concrete might be so deteriorated that, in isolated areas, the full depth of the deck slab must be removed. Where this occurs, formwork must be attached to the deck soffit and a full depth patch placed. On cathodic protection and waterproofing contracts the patch is placed to match the original deck elevation. On concrete overlay contracts, the concrete in the full depth repair is normally placed to cover the top mat of steel by approximately 25 mm using conventional (30 MPa or 35 MPa) concrete. This concrete is cured for a minimum of 72 h before sandblasting the deck. Occasionally, the full depth repair may be placed with the concrete overlay. However, this practice is undesirable because it is difficult to consolidate the concrete properly, it promotes cracking and the riding quality is impaired because of settlement of the concrete. Furthermore, latex-modified concrete is not intended to be used in thick sections. On post-tensioned decks, removal operations may puncture the void forms. If this occurs, the repair is treated the same as a full depth repair.

3.2.3/ Sandblasting

Not more than 24 h before application of a concrete overlay or the placing of concrete patches, the concrete surface and exposed reinforcing steel must be sandblasted. This includes the lower 50 mm of the curb face where a concrete overlay is to be placed. Sandblasting is carried out to produce a clean, sound surface which is free from contaminants. Form 930, which applies to concrete overlay contracts, places limits on the size of the compressor and the operating pressures and equipment to ensure that the production rate and the finished surfaces are satisfactory. It also requires that the work be done in sections of no more than 10 m^2 to minimize the possibility of areas being missed. The special provision contained in the supplement specifies the requirements for sandblasting areas of the deck to be patched in waterproofing and cathodic protection contracts. In all cases the deck must be surface dry at the time of sandblasting. If the deck is damp or wet the sandblasting is not only less effective but the sand adheres to the surface and is very difficult to remove.

Immediately after sandblasting, the sand must be removed from the deck and surrounding area. The deck should also be checked for concrete or aggregate particles which have been broken by the scarifying or chipping operations but not removed. Such particles should be removed using hand tools.

Compressors are not permitted on either exposed reinforcing steel or sandblasted areas of the deck to prevent oil drippings or the loosening of reinforcing bars.

3.2.4/ Deck Preparation for Cathodic Protection

In order for a cathodic protection system to function, any materials which would act as insulators must be removed prior to installing the conductive mix. These materials could include asphalt, waterproofing or epoxy. On structures with an exposed concrete deck, areas that have been patched with asphalt or concrete or areas that have been injected with epoxy should be removed and repaired with a permanent concrete patch with sawcut edges. Areas which have been injected with epoxy can be recognized by the presence of injection ports.

On structures with an asphalt wearing surface, the asphalt and waterproofing must be completely removed. The normal practice is to strip most of the asphalt from the deck using a power shovel, grader or scarifier. Care must be taken to ensure that the equipment does not create depressions, gouges or non-draining areas. If this occurs, the surface must be repaired with concrete patches. Where residual areas of asphalt or waterproofing remain, these are removed using chipping tools, a scabbler, or a bush hammer.

3.3/ Low-Slump Concrete Overlay

The procedure consists of the application of a 50 mm nominal thickness of a very low water-cement ratio (typically 0.32) air entrained Portland cement concrete overlay to the prepared deck surface. The low water-cement ratio is achieved by using a high cement factor (475 ± 6 kg/m^3) and a low-slump (maximum 25 mm) from which the method derives its name. Because of the very stiff concrete mixture used, a special finishing machine, with sufficient vibratory capacity to consolidate the concrete, must be utilized.

A thin coating of a mortar bonding grout is brushed into the dry deck surface no more than 2 m in front of the overlay concrete. Grout must also be applied to any vertical surfaces against which the overlay will be placed. The concrete is mixed on site using a continuous mixing plant. Requirements for the mixing unit and the calibration procedures are given in Form 930. The concrete is transported from the mixer to the point of placing using hand or, more commonly, motorized buggies. The deck surface must be protected from concrete or mortar droppings. Any exposed reinforcement in the path of the buggies must be covered with plywood. The concrete is distributed across the deck in front of the finishing machine, struck off by hand slightly above finished grade and consolidated and finished by the finishing machine.

Except where the deck is also to be waterproofed, trap-rock is used as the coarse aggregate in the concrete and the surface is grooved transversely using a wire broom or comb with a single row of tines. The trap-rock is used because of its resistance to polishing under traffic.

The final finishing must be completed within 20 min of the time the concrete is discharged from the mixing unit. In the event of an interruption in the placing of the concrete, the exposed edge of the overlay must be covered with wet burlap. If the delay exceeds 10 min, the grout applied to the deck must be removed. Where a prolonged delay is encountered, the Engineer may require a construction joint to be formed.

Two layers of wet burlap are applied to the overlay as soon as they can be supported without deformation of the concrete and not later than 30 min after texturing the concrete. The burlap must be held securely in place and kept wet by means of a mechanical sprinkling system for the first 24 h. For a further 48 h, the contractor has the choice of maintaining the sprinkling system in operation or placing a layer of polyethylene over the burlap.

Where a construction joint is shown on the plans, it is sawcut as soon as the concrete can be cut without plucking the aggregate. A minimum width of 75 mm is removed from all free edges of the overlay. The sawcut is made full depth in a single pass.

The specified overlay thickness of 50 mm is measured from the original deck surface (i.e., before scarifying). This means that the actual overlay thickness is the specified thickness of 50 mm plus the nominal 6 to 10 mm thickness removed in scarifying. Form 930 specifies an absolute minimum thickness of 45 mm. Where this requirement is not satisfied, the nominal thickness must be increased in the field until the minimum thickness is achieved without adversely affecting the riding quality of the deck.

More specific requirements for low-slump overlays, including constraints on placing operations and quality assurance procedures, are given in Form 930.

3.4/ Latex-Modified Concrete Overlay

The construction procedures for latex-modified concrete are similar to those for low-slump concrete overlays. The principal differences follow.

1/ The deck must be kept wet for at least one hour prior to applying the bonding grout. Excess water is blown off the deck immediately before placing the grout.

2/ The grout consists of a latex-modified mortar.

3/ The mixing equipment must have a means of storing and dispensing the latex modifier.

4/ The concrete has a high slump (180 ± 40 mm).

5/ The concrete is not air entrained.

6/ A conventional deck finishing machine fitted with a pan vibrator in front of the screed is used. The machines are equipped with a rotating cylinder screed.

7/ A combination of wet and dry curing is required.

8/ The specified thickness of overlay is nominally 40 mm (measured from the original deck surface before scarifying). The actual minimum thickness specified in Form 930 is 35 mm.

The deck must be wet down to assist in the latex penetrating the deck concrete and to prevent the latex from drying rapidly, thereby forming a film which would reduce bond strength. Although the cement content of the concrete is less (390 kg/m^3) and the slump is higher than low-slump concrete, the water-cement ratio is still very low (less than 0.40) because the latex acts as a water-reducer. The Ministry uses either styrene-butadiene or acrylic latexes meeting the requirements of Form 1312. Those products approved for use are given in the Ministry's Designated Sources List DS 100.3. In all cases the latex content is determined as 15% of latex solids by weight of cement. It is important to note that latex-modified concrete does not have to be air entrained for resistance to freezing and thawing. For this reason, the maximum air content (mainly entrapped air) is 6.5% but no minimum is specified.

Latex-modified concrete is more susceptible to plastic shrinkage cracking than conventional concrete mixtures. The timing of the texturing is also especially crucial. If the grooves are made too soon, they collapse and if the texturing is delayed beyond the time the latex film forms, the surface tears badly.

One layer of wet burlap is placed on the surface of the overlay as soon as it can be supported without deformation. A layer of polyethylene is placed over the burlap. After 24 h the wet curing is removed and the overlay allowed to air dry for a further 72 h in order to allow the latex particles to develop a continuous film which gives the concrete good bond, flexural strength and low permeability. The film forming properties of the latex are temperature-sensitive and develop very slowly at temperatures less than 10°C. Consequently, latex-modified concrete is more sensitive to temperatures in the curing period than conventional concrete and the curing period at temperatures less than 10°C may need to be extended significantly.

Quality assurance requirements for latex-modified concrete also differ from conventional concretes. These are specified in Form 930.

3.5/ Normal-Slump Concrete Overlay

The construction procedures for a normal-slump concrete overlay are also similar to those for low-slump concrete overlays. The main differences follow.

1/ Conventional 30 MPa, air entrained concrete is used in accordance with the requirements of Form 1350 except that the maximum aggregate size is 13.2 mm.

2/ The requirements for the finishing machine are the same as those for latex-modified concrete overlays.

3/ The overlay is normally waterproofed and paved, in which case trap-rock aggregate and texturing are not required.

The continuous on-site mixer is not necessary and the concrete is usually supplied from transit mixers. There are fewer requirements for normal-slump overlays than either low-slump or latex-modified concrete overlays and these are specified in Forms 1350 and 930.

3.6/ Patch, Waterproof and Pave

This rehabilitation scheme involves repairing deteriorated areas of the deck by placing concrete patches, followed by the application of a waterproofing membrane, protection board and two 40 mm thick lifts of bituminous concrete.

The methods of identifying areas of delamination and of removing the unsound concrete are described in Section 3.2.2. After removing the unsound concrete, the areas to be patched are sandblasted in the same way as is done prior to application of a concrete overlay. A mortar bonding grout is applied to the patch areas and 30 MPa concrete (35 MPa on post-tensioned structures) is placed and finished level with the original deck surface. Curing requirements are to cover the concrete with two layers of wet burlap and opaque polyethylene for a minimum of 72 h. Proper placement and curing of the concrete patches is crucial to the success of this method of rehabilitation and requires the same quality of construction as for a concrete overlay. Specific requirements for the work are given in the Special Provision contained in the Supplement.

After the concrete has cured, the entire deck surface is sandblasted and waterproofed in accordance with the requirements of Form 914. The Ministry uses two types of waterproofing membrane, hot-applied rubberized asphalt and hot-applied rubberized mastic. The mastic is only permissible on rigid frame structures, where its lack of flexibility at low temperatures is not a serious impediment, but it is specified only infrequently and rubberized asphalt is preferred. A protection board is not required when mastic is used.

The specified thickness of the waterproofing is a minimum of 4 mm and a maximum of 6 mm. The thickness must be carefully controlled during application. The waterproofing is heated on-site using an oil-jacketted kettle and applied to the deck surface and the bottom 90 mm of the curb faces with a squeegee. Where a chase is provided, the membrane is terminated in the chase. The work must be done by an approved applicator. The method of approving applicators is the responsibility of the manufacturers of the products which are approved by the Ministry and contained in the Ministry's Designated Sources List DS 191.1. Acceptance guidelines are given in Ministry Directive C-141. A protection board is used in conjunction with rubberized asphalt to prevent damage to the membrane when placing the hot mix and to prevent penetration by aggregate particles from the hot mix under traffic loading. The protection board is placed with a maximum overlap of 25 mm.

Where a crack exists at a construction joint in the deck, a 450 mm wide strip of preformed rubber membrane (specified in Form 914) is placed in the waterproofing membrane over the joint. The same treatment may be specified on the drawings for other significant cracks resulting from other causes. Where it is anticipated that the crack will reflect through the bituminous surfacing, a 20 mm x 20 mm groove should be sawn or routed in the surfacing over the crack and filled with a hot-poured rubberized asphalt joint sealing compound listed in the Ministry's Designated Sources List DS 143.4.

The hot mix paving must be completed within one week of the waterproofing to prevent curling of the edges of the protection board which could induce cracks in the hot mix. The paving is carried out in accordance with Form 310.

Additional information on waterproofing is contained in the Ministry's Manual for Bridge Deck Waterproofing.

3.7/ Cathodic Protection

3.7.1/ Introduction

The theory of cathodic protection is to apply sufficient current to the surface of the reinforcing steel to prevent it from discharging ions so that corrosion does not occur. This is done by placing anodes to distribute current evenly over the concrete surface. The steel then becomes a cathode with respect to the external anodes; hence the term cathodic protection. Power is supplied to the anodes in the form of a very low direct current from a rectifier which, in turn, is connected to a mains supply. The key to successful cathodic protection of steel in concrete is to provide a uniform current density to the reinforcement. If the current density is too low, corrosion can occur: if it is too high, deterioration of the concrete around the bars may take place.

A schematic representation of the cathodic protection system used by the Ministry is shown in Figure 1. Current flows from the rectifier to "pancake" shaped cast iron anodes positioned in recesses on the deck. These are termed primary anodes. A 40 mm thick layer of electrically conductive asphalt is placed on the deck. This acts as a secondary anode and distributes the current from the primary anodes over the entire deck surface. The current then flows through the concrete to the reinforcing steel. The conductivity is achieved by incorporating carbon particles in the form of coke breeze in the bituminous mixture. The electrical circuit is completed by connecting the reinforcing steel to the negative terminal of the rectifier.

3.7.2/ Design

The design of a cathodic protection system involves determining the number and location of the anodes, ground connections, half-cells and voltage probes. The legend shown in Figure 2 should be used on all drawings to identify the various components.

Figure 1/ Cathodic Protection Circuit

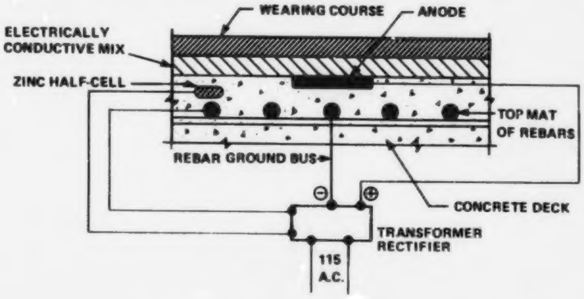
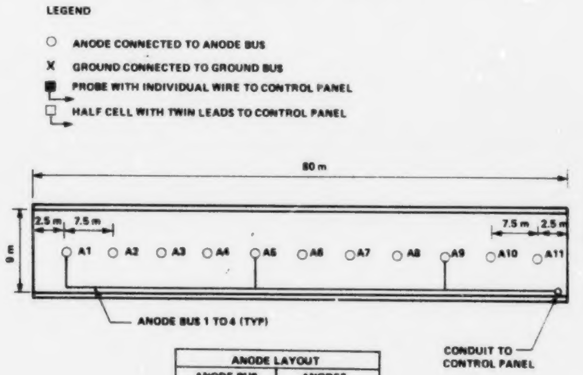


Figure 2/ Typical Placement of Anodes on a Long Narrow Bridge and Legend


LEGEND
○ ANODE CONNECTED TO ANODE BUS
X GROUND CONNECTED TO GROUND BUS
■ PROBE WITH INDIVIDUAL WIRE TO CONTROL PANEL
☐ HALF CELL WITH TWIN LEADS TO CONTROL PANEL
80 m
9 m
2.5 m
7.5 m
7.5 m
2.5 m
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
ANODE BUS 1 TO 4 (TYP)
CONDUIT TO CONTROL PANEL

ANODE LAYOUT	
ANODE BUS	ANODES
1	A1, A5, A9
2	A2, A7, A11
3	A3, A6, A10
4	A4, A8

The following gives general requirements for the layout of cathodic protection hardware. However, there may be cases where adjustments have to be made to accommodate staging requirements. For example, if one side of a deck can be closed to traffic for a short time only, as might be the case for a ramp structure, all the wiring can be run to one side of the deck. Such a case is illustrated in Figure 3.

3.7.2.1/ Anodes

The anodes are located so that power is distributed uniformly along and across the deck. The top reinforcing steel in all parts of the deck must be polarized to a potential within the range -0.80 to -1.25 V for the cathodic protection to be effective. One anode should be provided for each 50 to 75 m² of deck area. The location of the anodes is determined as follows.

1/ For bridge decks 10 m or less in width, curb to curb, use a single line of anodes down the centre of the deck.

2/ For bridge decks 10 m to 20 m, use two lines of anodes along the deck, each line spaced 3 m from each curb.

3/ For bridges greater in width than 20 m, use three lines of anodes. Use two lines of anodes, each spaced 3 m from each curb, and one line down the centre of the deck. If this results in a spacing between anode lines of more than 15 m, use additional anode lines as necessary.

4/ The spacing of the anodes from each other in each line must not exceed 7.5 m. The end anode in each line must not be more than 3 m from the end of the deck. If the deck is in sections separated by expansion joints or fixed joints, the end anode must not be more than 3 m from each joint in each section.

Where it is indicated that the anodes are placed down the centre of the deck, they may be offset slightly to facilitate staging.

Examples of anode placements on decks of different sizes are shown in Figures 2 to 5. Some of the figures also show the placement of rebar ground connections, half-cells and voltage probes. These are discussed in Sections 3.7.2.2 to 3.7.2.4.

Figures 2 to 5 show how the position of each anode string relative to the end of the deck and the intermediate anode spacings may be varied to achieve an even spacing of the anodes on a deck. Figure 3 illustrates the case of an irregular-shaped deck where additional anodes are required at the wider end to provide an even distribution of power. No more than four, and preferably three, anodes should be connected to each feeder line from the rectifier. However, in Figure 3, one feeder line has five anodes because of the irregular shape of the deck. It is desirable that the feeder lines supply power to anodes which are widely separated on the deck so that, in the event of loss of power in one feeder line, a large section of the deck is not left entirely without protection. If some feeder lines are considerably longer than others, this can be compensated by placing low value resistors in series with the lines in order to even out the voltage at each anode.

Each anode is recessed 50 mm in the deck so that its top surface is flush with the deck surface. Any rebars intercepting the recess are cut out flush with the walls of the recess as illustrated in Figure 6 and the cut ends insulated with epoxy paste.

3.7.2.2/ Rebar Ground Locations

Several ground connections are made to the rebars along the entire length of the bridge. This is done to ensure that no part of the steel reinforcement is isolated electrically and to prevent any significant voltage drop along the length of the structure. A useful guide to determine the number of ground locations is one per 100 m² of deck area with a minimum of four per structure.

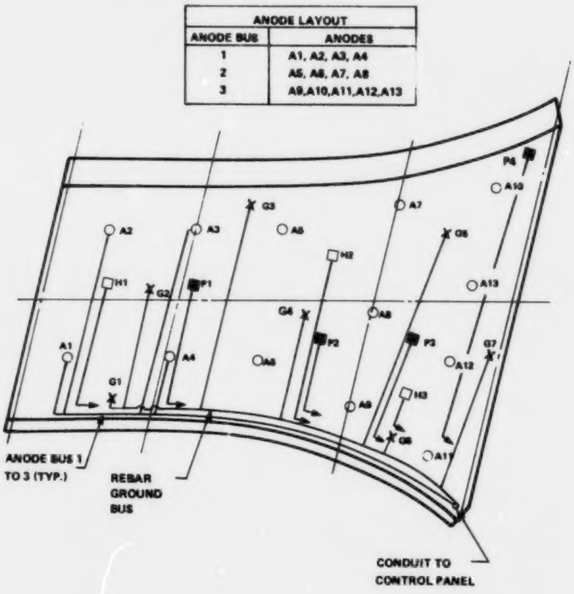
At each ground location, the wire must be thermite welded to the rebar and connected to a #6 stranded bus wire running to the control panel.

3.7.2.3/ Half-Cells

Zinc-zinc sulphate half-cells are used to control the rectifier to maintain the polarized potential of the rebars within the acceptable range. Although only one half-cell is used to control the rectifier at any one time, the half-cells are prone to failure hence a minimum of three are placed in each deck. Typical locations for the half-cells are shown in Figures 3, 4 and 5.

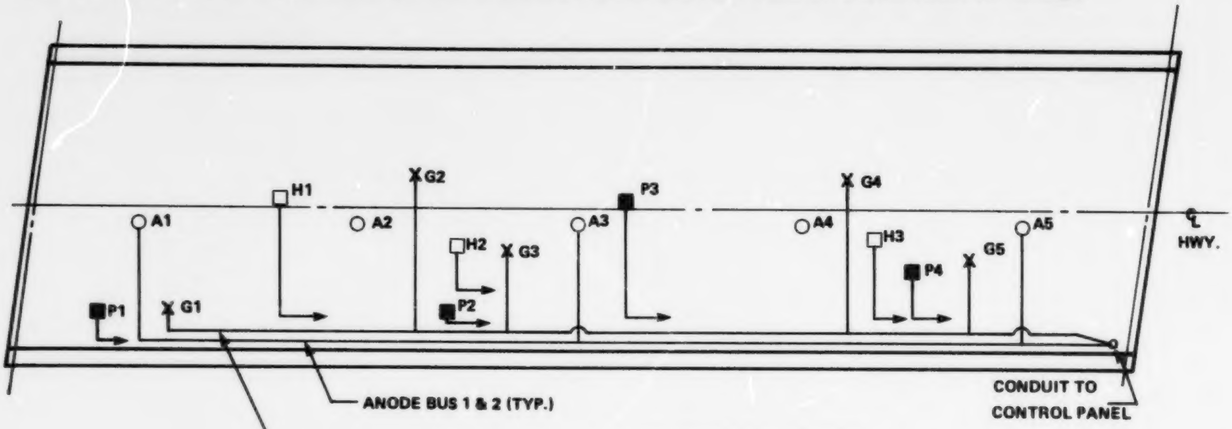
The method of placing each half-cell in a recess in the deck is shown in Figure 7. The half-cell is located near an exposed rebar. A half-cell ground wire is thermite welded to the rebar and run to the control panel with the half-cell lead wire.

Figure 3/ Typical Placement of Anodes, Rebar Grounds, Probes and Half-Cells on an Irregularly Shaped Bridge



ANODE LAYOUT	
ANODE BUS	ANODES
1	A1, A2, A3, A4
2	A5, A6, A7, A8
3	A9,A10,A11,A12,A13

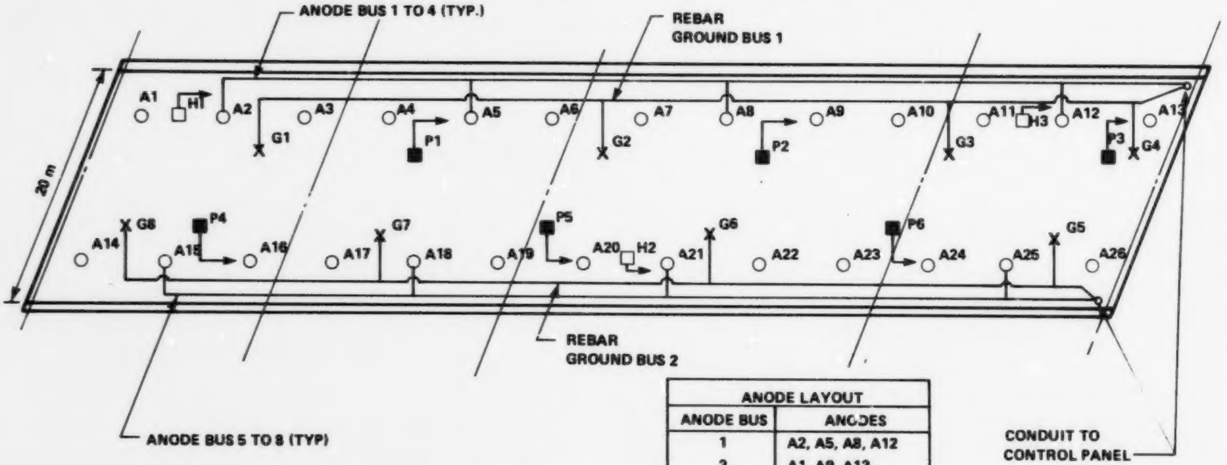
Figure 4/ Typical Placement of Anodes, Rebar Grounds, Probes and Half-Cells on a Short Narrow Bridge


H1
G2
P3
G4
A1
A2
A3
A4
A5
H2
G3
H3
P4
G5
℄ HWY.
P1
G1
P2
ANODE BUS 1 & 2 (TYP.)
REBAR GROUND BUS
CONDUIT TO CONTROL PANEL

ANODE LAYOUT	
ANODE BUS	ANODES
1	A1, A3, A5
2	A2, A4

NOTE : ANODES LOCATED SLIGHTLY OFF CENTRE
TO ALLOW FOR TRAFFIC STAGING.

Figure 5/ Typical Placement of Anodes, Rebar Grounds, Probes and Half-Cells on a Wide Bridge


ANODE BUS 1 TO 4 (TYP.)
REBAR GROUND BUS 1
20 m
A1
H1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
H3
A12
A13
G1
P1
G2
P2
G3
P3
G4
G8
P4
G7
P5
G6
P6
G5
A14
A15
A16
A17
A18
A19
A20
H2
A21
A22
A23
A24
A25
A26
REBAR GROUND BUS 2
ANODE BUS 5 TO 8 (TYP)
CONDUIT TO CONTROL PANEL

ANODE LAYOUT	
ANODE BUS	ANODES
1	A2, A5, A8, A12
2	A1, A9, A13
3	A3, A7, A11
4	A4, A6, A10
5	A15, A18, A21, A25
6	A14, A22, A26
7	A16, A20, A24
8	A17, A19, A23

Figure 6/ Anode Recess

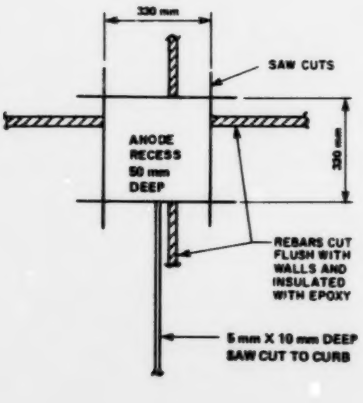
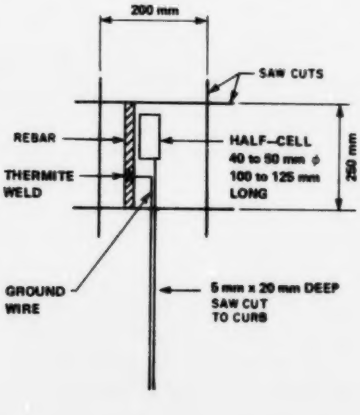

330 mm
SAW CUTS
ANODE RECESS 50 mm DEEP
330 mm
REBARS CUT FLUSH WITH WALLS AND INSULATED WITH EPOXY
5 mm X 10 mm DEEP SAW CUT TO CURB

Figure 7/ Half-Cell Installation Detail


200 mm
SAW CUTS
REBAR
THERMITE WELD
HALF–CELL 40 to 50 mm ϕ 100 to 125 mm LONG
250 mm
GROUND WIRE
5 mm x 20 mm DEEP SAW CUT TO CURB

3.7.2.4/ Voltage Probes

Graphite probes are distributed over the deck to sense the applied and polarized potentials of the reinforcing steel. These probes are also placed in recesses in the deck as shown in Figure 8 and installed flush with the deck surface. The lead wire is run to the control panel.

The voltage probes are used to sense the range of potentials in the deck. Consequently, they should be positioned in areas where the potential is expected to be low and close to anodes where the potential may exceed the recommended range. Low potentials frequently occur near the ends of decks, in the acute corners of skewed decks and, in the case of decks powered by a single row of anodes at the centre line, near the curbs. Consequently, probes should be placed in the "problem" areas as well as in locations more representative of the deck as a whole. Typical locations are shown in Figures 3, 4 and 5. A useful guide is to install one voltage probe per 200 m² of deck area with a minimum of four per bridge and the addition of probes in "problem" areas.

3.7.2.5/ Electrical Wiring

The anodes, half-cells, voltage probes and rebar grounds are connected by wires to the control panel. The wires are placed in slits cut on the deck surface and run to the curb where they are bundled and cast in a concrete fillet strip as shown in Figure 9. Where the wires cannot be routed on the curb side of deck drains (by chipping the curb if necessary), asphalt drainage tubes must be provided at each drain as shown in Figure 10. At a convenient location, the wires pass through a hole in the deck into plastic conduit to the control panel. For most bridges, a 100 mm diameter hole and 75 mm conduit are suitable. On larger structures, where there are a considerable number of wires involved, larger conduit is needed, particularly where the direction of the wires is changed at a junction box.

If the deck has several sections, separated by expansion joints or fixed joints, the fillet strip must be terminated and the wires routed around the joint. This is done by core-drilling a hole through the deck and either routing the wires in plastic conduit to the control panel or back into the concrete fillet on the other side of the joint by drilling another hole through the deck. In the former case, an expansion fitting is installed in the conduit; in the latter, the wires are formed into an expansion loop. In cases where a large haunch must be by-passed, conduit should be used.

It is important that the conduit enter the control panel from the bottom, as shown in Figure 11. There is always seepage of some moisture from the deck into the conduit and this would cause corrosion within the control panel. A 10 mm diameter hole is drilled in each of the L-B's below the level of the panel to allow any water present to drain out of the conduit. The conduit is fastened to the structure using either galvanized or aluminum straps.

3.7.2.6/ Control Panel and Rectifier

One control panel and one rectifier are sufficient for decks up to 200 m in length. On longer decks, two rectifiers and control panels should be used, each feeding half the deck. They can be placed at opposite ends of the deck, or at the same end, whichever is the more convenient.

The control panel and rectifier are normally located beneath the bridge, preferably on a face of the wingwall rather than the abutment face. The location should be chosen such that the housings are not exposed to salt splash or the possibility of joint leakage or flooding. At sites vulnerable to vandalism, a location above the deck surface may be necessary. They must not be mounted on the diaphragm (or any part of the bridge superstructure) to avoid vibration.

Figure 8/ Voltage Probe Installation Detail

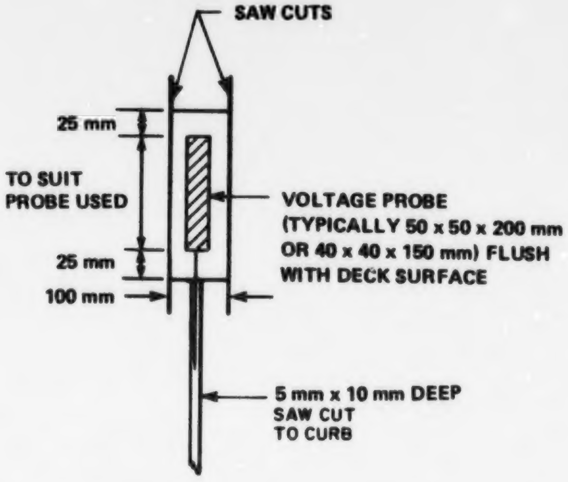

SAW CUTS
25 mm
TO SUIT
PROBE USED
VOLTAGE PROBE
(TYPICALLY 50 x 50 x 200 mm
OR 40 x 40 x 150 mm) FLUSH
WITH DECK SURFACE
25 mm
100 mm
5 mm x 10 mm DEEP
SAW CUT
TO CURB

Figure 9/ Section Showing Anode in Recess and Wires at Curb

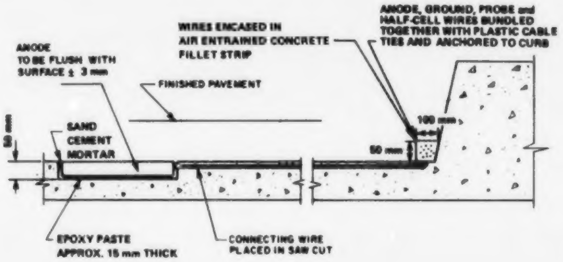
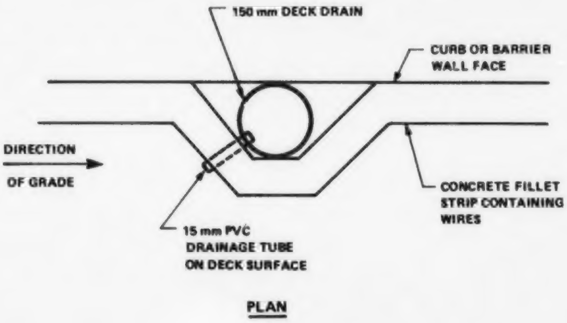

ANODE
TO BE FLUSH WITH
SURFACE ± 3 mm
WIRES ENCASED IN
AIR ENTRAINED CONCRETE
FILLET STRIP
ANODE, GROUND, PROBE and
HALF-CELL WIRES BUNDLED
TOGETHER WITH PLASTIC CABLE
TIES AND ANCHORED TO CURB
FINISHED PAVEMENT
50 mm
SAND
CEMENT
MORTAR
100 mm
50 mm
EPOXY PASTE
APPROX. 15 mm THICK
CONNECTING WIRE
PLACED IN SAW CUT

Figure 10/ Detail of Fillet Strip at Drains


150 mm DECK DRAIN
CURB OR BARRIER
WALL FACE
DIRECTION
OF GRADE
CONCRETE FILLET
STRIP CONTAINING
WIRES
15 mm PVC
DRAINAGE TUBE
ON DECK SURFACE
PLAN

Power from a 115 V (or 230 V) supply line is run to the bridge and terminated in a supply control cabinet. This must be provided with twin grounds as shown in Figure 11. The components and wiring within the supply control cabinet are shown in Figure 12.

The wiring within the control panel is a function of the number of connections to be made. Typical details are given in Figure 13. Additional information on the sequence of connection and adjustments is given in the Ministry's report SP-81-01 "Cathodic Protection for Concrete Bridge Deck Restoration."

3.7.3/ Construction

The method of removing any existing hot-mix, unsound concrete and patching the deck with concrete is described in Sections 3.2 and 3.6.

After the concrete patches have cured, recesses are cut in the deck surface to accommodate the anodes, voltage probes and ground connections.

Anode recesses are 50 mm deep and may be moved 150 mm in any direction so that the minimum number of rebars have to be cut in making the recess. After the anode recesses have been prepared, any exposed rebars in the bottom or cut rebar ends in the sides of the recess must be painted with a thick layer of epoxy resin. The slit from the anode location to the curb is cut 15 mm deep and 10 mm wide using dry sawing. A layer of epoxy thickened with fibres or other suitable filler is placed approximately 15 mm thick in the bottom of the recess and the anode installed. Shims of an electrically non-conductive material may be placed under the anode so that the top of the anode does not sink in the epoxy and remains level with the deck surface as shown in Figure 9. The insulating layer is used to avoid "hot spots" in the deck beneath the anodes and ensure that the current is distributed through the secondary anode. For this reason, the top surface of the primary anodes must be clean when the conductive layer is applied. This requirement is satisfied by covering the top surface of the anodes with adhesive tape which is removed just prior to paving. After the epoxy paste has set, the area between the anode and the side of the recess is filled with a sand-cement mortar. The connecting wire is pressed into the slit which is then filled with epoxy paste.

Rebar ground connections are made by exposing the upper surface of a short length of rebar, cleaning the bar and thermite welding the ground wire to it. After the weld has cooled, the connection is covered with a silicone rubber sealant. The lead wire is installed in a slit 5 mm x 10 mm deep in the same way as anode lead wires and the recess is back-filled with epoxy paste.

Half-cells are installed in recesses cut to expose approximately 250 mm of a rebar. A ground wire is thermite welded to the rebar as described above. The exposed rebar is coated with mortar to a thickness of approximately 5 mm. The zinc-zinc sulphate half-cell is placed against the mortar after it has dried. The slit for the lead wires must be 20 mm deep to accommodate the ground wire and the half-cell lead wire. The recess is back-filled with concrete and the sawcuts with epoxy paste.

The voltage probes are installed in recesses located midway between rebars. The probes are set in mortar to be flush with the deck surface. The upper surface of the probe is protected with adhesive tape in the same way as the anodes.

The most important task in installing cathodic protection is to ensure that all connections are secure and that there is no possibility of a short-circuit between the primary anodes or the conductive layer and the reinforcing steel. Such a

Figure 11/ Arrangement of Electrical Boxes and Conduit

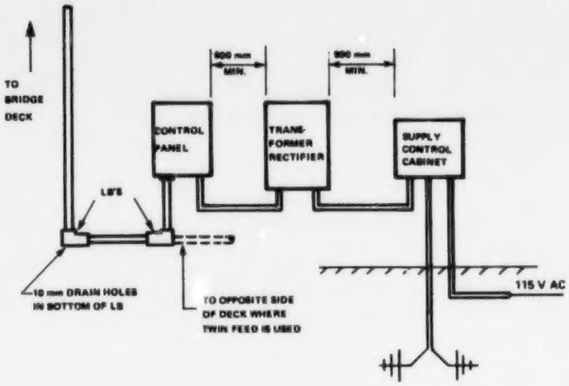
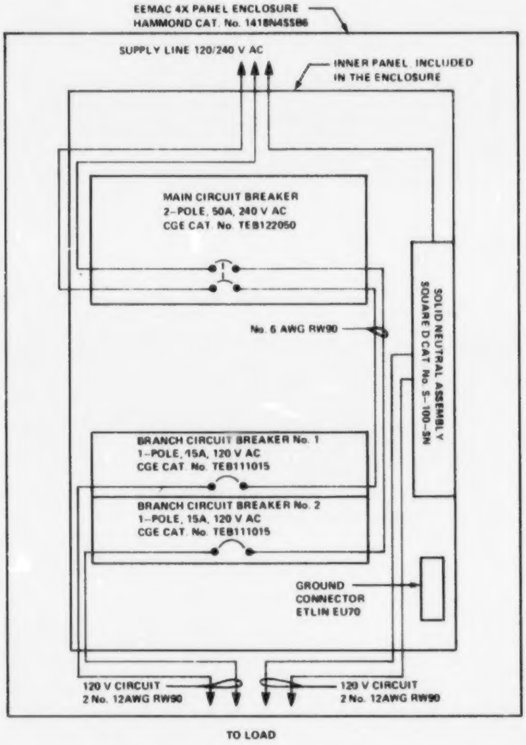

TO BRIDGE DECK
900 mm MIN.
900 mm MIN.
CONTROL PANEL
TRANS-FORMER RECTIFIER
SUPPLY CONTROL CABINET
LB'S
10 mm DRAIN HOLES IN BOTTOM OF LB
TO OPPOSITE SIDE OF DECK WHERE TWIN FEED IS USED
115 V AC

Figure 12/ Layout and Components of Supply Control Cabinet


EEMAC 4X PANEL ENCLOSURE HAMMOND CAT. No. 1418N4SSB6
SUPPLY LINE 120/240 V AC
INNER PANEL INCLUDED IN THE ENCLOSURE
MAIN CIRCUIT BREAKER 2-POLE, 50A, 240 V AC CGE CAT. No. TEB122050
No. 6 AWG RW90
SOLID NEUTRAL ASSEMBLY SQUARE D CAT. No. S-100-SN
BRANCH CIRCUIT BREAKER No. 1 1-POLE, 15A, 120 V AC CGE CAT. No. TEB111015
BRANCH CIRCUIT BREAKER No. 2 1-POLE, 15A, 120 V AC CGE CAT. No. TEB111015
GROUND CONNECTOR ETLIN EU70
120 V CIRCUIT 2 No. 12AWG RW90
120 V CIRCUIT 2 No. 12AWG RW90
TO LOAD

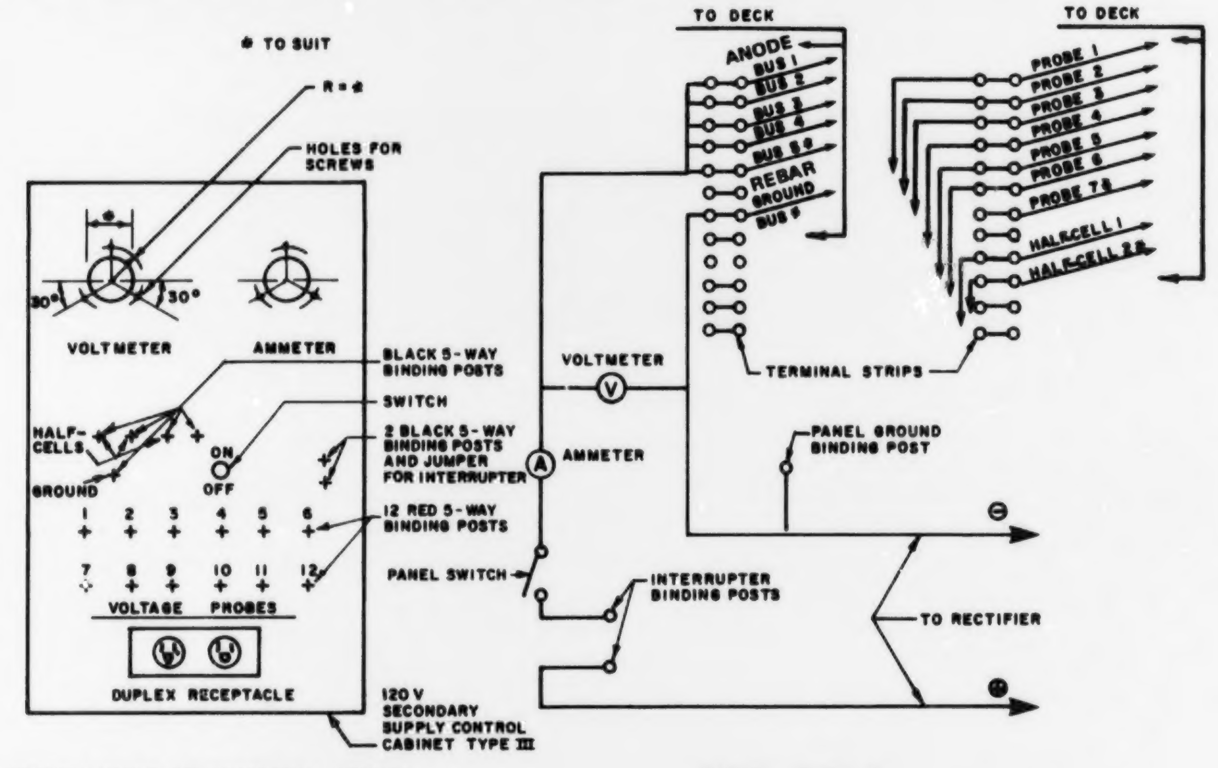
short-circuit could be directly to the rebars or indirectly through such items as deck drains or expansion joints. Prior to paving, the wiring must be checked very carefully to ensure there are no short-circuits. Any defects must be identified and corrected. The entire deck surface must also be checked for exposed metal such as rebars or tie wires which could act as shorts. If any are found, these must be covered with two layers of epoxy resin.

After the electrical wiring has been completed, the wires along the curb are bundled using plastic wire ties which are anchored to the deck or curb. The wires are then encased in a concrete fillet strip.

The electrically conductive asphalt is placed using conventional paving equipment. Timbers 150 mm wide are placed along any metal expansion joints or rectangular drain scuppers. For circular drains, it is usual to pave up to the pipes and cut back the conductive layer for a distance of 150 mm after compaction. The areas adjacent to the drains and joints are filled in when the (non-conductive) wearing course is placed.

Standard Special Provisions for the application of cathodic protection are available.

Figure 13/ Typical Front View of Control Panel and Panel Wiring


* TO SUIT
R = *
HOLES FOR SCREWS
*
30°
30°
VOLTMETER
AMMETER
BLACK 5-WAY BINDING POSTS
SWITCH
HALF-CELLS
ON
OFF
GROUND
2 BLACK 5-WAY BINDING POSTS AND JUMPER FOR INTERRUPTER
12 RED 5-WAY BINDING POSTS
1
2
3
4
5
6
7
8
9
10
11
12
VOLTAGE PROBES
DUPLEX RECEPTACLE
120 V SECONDARY SUPPLY CONTROL CABINET TYPE III
TO DECK
ANODE
BUS 1
BUS 2
BUS 3
BUS 4
BUS 5*
REBAR
GROUND
BUS 6
TO DECK
PROBE 1
PROBE 2
PROBE 3
PROBE 4
PROBE 5
PROBE 6
PROBE 7*
HALF-CELL 1
HALF-CELL 2*
VOLTMETER
V
A
AMMETER
TERMINAL STRIPS
PANEL GROUND BINDING POST
PANEL SWITCH
INTERRUPTER BINDING POSTS
TO RECTIFIER
⊖
⊕

FRONT VIEW OF CONTROL PANEL

CONTROL PANEL WIRING SHALL BE 12 AWG STRANDED COPPER INSULATED WIRE

PANEL WIRING

4/ CONTRACT DOCUMENTS

4.1/ Drawings

4.1.1/ Introduction

The drawings discussed in this section make up the structural component of the rehabilitation contract. The requirements for the preparation of drawings for the other parts of the contract (grading, electrical, etc.) are detailed in other MTC manuals. Drawings required as part of the structural component should include a General Arrangement Drawing together with detail drawings as required.

General design and drafting requirements for structure drawings can be found in the MTC Structural Manual.

4.1.2/ General Arrangement Drawing

The following is a list of details which should be included when preparing a general arrangement drawing:

- a plan of the structure;
- a side elevation of the structure;
- a cross-section or sections of the structure showing the existing conditions and the proposed treatment;
- a key plan showing the location of the structure site (if not shown elsewhere);
- suggested construction sequence and staging;
- general notes to the contractor;
- list of structural drawings.

4.1.3/ Detail Drawings

It is not practical to list all the details which may be required for each type of rehabilitation contract. The extent and number of details will vary with the complexity of the individual project. Table 4 includes a column which gives guidance to where detail drawings may be needed. Where there is no entry in this column, detail drawings are not required.

4.1.4/ Profile Data

In order to avoid problems associated with uneven riding surfaces, poor drainage, insufficient or excessive thickness and improper joint settings, it is preferable that elevations be provided to define the new profile. This is done by analysing the data collected as described in Section 2.7.

The new profile should be established to satisfy the conditions outlined below.

- Eliminate existing drainage deficiencies and provide adequate crossfall and grade.
- Provide the required thickness of asphalt (bituminous concrete surfaces).
- Ensure that the requirements for minimum overlay thickness are satisfied while keeping overlay quantities to a minimum (concrete overlays).
- Specify joint elevations so that concrete end dams match the finished pavement surface and the joint assembly is recessed 5 mm.
- Specify deck drain elevations to provide proper drainage.
- Provide a smooth transition between the new pavement and the existing approach pavement.

Where it is not possible to specify profile data on the drawings, the responsibility for establishing profiles must be assumed by field staff.

4.1.5/ Existing Structure Drawings

Where drawings of existing structures are available, they can be included in the contract documents for reference purposes in either of two ways:

1/ Adding the drawings to the contract documents; or

2/ Making the drawings available for inspection at a specified location. SP 185 has been written to cover this situation.

Table 4/ Tender Items, Conditions for Use and Requirements for Detail Drawings

Tender Item	Unit	Spec.	Conditions for Use of Tender Items	Details to be Shown on Drawings
Scarifying Deck	m²	930 SP(NSP)	Used with all concrete overlay projects except where the deck is badly deteriorated to a substantial depth (e.g., deep scaling under asphalt). In such cases, prepare a non-standard SP for scabbling or use hand chipping.	Extent and depth of scarifying.
Removal of Concrete	crew hour	930 SP (NSP)	Covers removal of deteriorated concrete from the deck or when installing new joints. A non-standard SP is required to adjust work unit if other than as stated in Form 930. If crew hour quantity is less than 20, consider using extra work provisions of Form 100 (see Directive C-86).	Extent of removal at joints.
Removal of Concrete from Deck Soffit and Substructure	crew hour	SP (NSP)	Covers removal of deteriorated concrete from deck soffit and substructure.	Extent of removal on deck soffit and substructure.
Rental of Airhammer(s) (operated)	h	930	Used in conjunction with the items for the removal of concrete to adjust crew size.	

Table 4/ Tender Items, Conditions for Use and Requirements for Detail Drawings (cont'd.)

Tender Item	Unit	Spec.	Conditions for Use of Tender Items	Details to be Shown on Drawings
Removal of Structure	lump sum	510 904 SP (NSP)	Used to designate portion of structure to be removed (e.g., curb, sidewalk, parapet wall). Does not apply to ballast wall removal (use "Removal of Concrete").	State items to be removed (e.g., curb, parapet wall). Show extent of removal, location of sawcuts, treatment of existing reinforcing steel and treatment of concrete surface prior to placing new concrete.
Sandblasting Deck	lump sum	930	Used with all concrete overlay projects in accordance with Form 930. Sandblasting prior to waterproofing is included in Form 914. Sandblasting prior to patching is included in the non-standard SP "Concrete Patches in Deck". Sandblasting prior to placing concrete at new joint assemblies is included in the non-standard SP, "Supply and Install Joint Assemblies".	
Sandblasting Reinforcing Steel	m^2	930	Used only as a separate pay item in conjunction with concrete overlays.	
Place Latex-Modified Concrete Overlay	m^3	930	Used for concrete overlays.	State type of overlay. Show overlay thickness from original deck surface and limits in plan and cross-section. Detail any geometrical conditions which may affect the contractors' operations, choice of equipment or number of placing operations.
Place Low-Slump Concrete Overlay	m^3	930		
Place Normal-Slump Concrete Overlay	m^3	930		
Finish, Texture and Cure Latex-Modified Concrete Overlay	lump sum	930	Used when the concrete overlay will be the wearing surface.	
Finish, Texture and Cure Low-Slump Concrete Overlay	lump sum	930		
Finish, Texture and Cure Normal-Slump Concrete Overlay	lump sum	930		
Finish and Cure Latex-Modified Concrete Overlay	lump sum	930	Used when a waterproofing membrane and hot-mix will be installed over the concrete overlay.	
Finish and Cure Low-Slump Concrete Overlay	lump sum	930		
Finish and Cure Normal-Slump Concrete Overlay	lump sum	930		
Supply and Install Joint Assemblies	lump sum	510 920 SP (956, 190.03) SP (NSP)	Covers the installation of new joint assemblies with anchorages embedded in new concrete work. Concrete removal is carried out as a separate item. A non-standard SP is required to define preparation of the recess prior to placing concrete around joint anchorage. Remove any existing styrofoam at joints by extra work procedures.	Show the following: • existing conditions and new joint assembly, • location of sawcuts, • extent of concrete removal, • treatment of existing reinforcing steel and existing concrete surface prior to placing new concrete, • joint anchorage and additional reinforcing steel, • setting and levelling devices, • installation temperature. • notes to contractor.
Modification of Deck Expansion Joints	lump sum	510 920 SP (956, 190.03) SP (NSP)	Used where extensive concrete work is not required e.g., new joints are welded to existing hardware. Non-standard SP required to define treatment at curb. Remove any existing styrofoam at joints by extra work procedures.	Show existing conditions and new joint assembly, method of attachment to existing joints, treatment at curb, setting and levelling devices, installation temperature and note to contractor.
Concrete in Ballast Wall	lump sum	904 SP (NSP)	Used when ballast wall is to be reconstructed.	Limits of removal and details of new construction.
Concrete in Approach Slab	lump sum	904 SP (NSP)	Used when approach slab is to be reconstructed.	Limits of removal and details of new construction.

Table 4/ Tender Items, Conditions for Use and Requirements for Detail Drawings (cont'd.)

Tender Item	Unit	Spec.	Conditions for Use of Tender Items	Details to be Shown on Drawings
Deck Drains	each	904 SP (NSP)	Used when installing new deck drains.	Location of new and existing drains, method of installation, new drain details as per Standard SS 9-1A, 9-4A, 9-5A.
Modification of Deck Drains	each	914 510 SP (952)	Used when existing drains will be extended upward or downward.	Existing conditions and size, locations and method of attachment of extensions (upward or downward). Detail as per Standards DD-3901, -3902, -3904.
Supply and Install Bearings	each	904 906, SP (NSP) SP (910)	Used where bearings must be replaced or added. 904 may be required for concrete structures or 906 for a steel structure.	Show the following: • existing conditions and new bearings, • locations of jacking points and jacking forces, • sequence of construction, • setting and levelling procedures, • anchorage details, • notes to contractor.
Supply and Install Drainage Tubes in Deck	each	SP (NSP)	Used to drain water which collects above a waterproofing membrane or in an electrically conductive mix. Usually involves the installation of 25 mm diameter tubes at the low corners of the deck.	Location of drains method of installation (DD-3951).
Bridge Deck Waterproofing	lump sum	914 SP (905, 907, 952)	Used when structure is to be waterproofed. Form 914 is used for waterproofing. Standards SP's 905, 907 and 952 are required to amend Form 914 with respect to temperature restrictions, type of membrane and basis of payment.	DD-1209-A or -B Extent of waterproofing. Show in cross-section where limits may be ambiguous (e.g., mountable curb). Show location of rubber membrane and "form-and-fill grooves" if other than as shown in DD-1209-A or -B.
Access to Work Area	lump sum	919 SP (NSP)	Used where access to work on the deck soffit or substructure involves significant cost or where the bid price of such access may be duplicated in multiple operations. Payment is covered by a non-standard SP.	
Temporary Support	lump sum	919 SP (NSP)	Used where it is necessary to provide temporary support to the structure during rehabilitation. Examples are during jacking operations to replace bearings or when staging would cause an overload condition.	Show location and details of temporary support.
Concrete Patches in Deck	m³	904 SP (NSP)	Used for deck repair prior to installing a waterproofing membrane or cathodic protection.	Details of repair procedures.
Embedded Work in Structure for Cathodic Protection	lump sum	913 SP (916)	Used for cathodic protection.	Location and details of installation of all hardware and routing and lead wires. Special treatment may be required at deck drains or joints.
Surface Work on Structure for Cathodic Protection	lump sum	SP (915)	Used for cathodic protection.	Location of rectifier and control panel, routing and size of conduit. Electrical equipment support system.
Items Associated with Supply of Power to Operate Cathodic Protection System**			Used for cathodic protection.	Location, type and size of all hardware, ducts and wire.
Dowels into Concrete	each	904	Used when steel dowels must be attached to the existing structure e.g., when placing a new barrier or ballast wall.	Location, size and length. Method of installation.
Sandblasting prior to Latex-Modified Shotcrete	m²	SP (NSP)	Used in conjunction with latex-modified shotcrete.	

Table 4/ Tender Items, Conditions for Use and Requirements for Detail Drawings (cont'd.)

Tender Item	Unit	Spec.	Conditions for Use of Tender Items	Details to be Shown on Drawings
Latex-Modified Shotcrete Test Panels	each	SP (NSP)	Used in conjunction with latex-modified shotcrete.	
Latex-Modified Shotcrete	m³ or m²	SP (NSP)	Used for latex-modified shotcrete repair of deck soffit or substructure.	Typical details showing repair areas, requirements for wire mesh, formwork and final surface.
Reinforcing Steel	t	905 SP (954)	Used when new reinforcing steel is required.	Location and size as required.
Coated Reinforcing Steel	t	905 SP (954)	Used when coated reinforcing steel is added to the structure.	Location and size as required.
Concrete in Barrier Walls	lump sum	904	Used when new barrier walls are installed.	Location and section, detail as per Std. SS 110-10, -11, -12. Concrete quantity shown on P Q P sheet.
Concrete in Parapet Walls	lump sum	904	Used when new parapet walls are installed.	Location and section, detail as per Std. SS 110-1. Concrete quantity shown on P Q P sheet.
Steel Barrier Rail	lump sum	908 SP (955)	Used in conjunction with a concrete barrier wall where there is a sidewalk.	Detail as per Std. SS 110-21.
NOTE:—The following Tender Items will normally be prepared by the Regional Planning and Design Section rather than the Structural Section.				
Removal of Bituminous Pavement from Concrete Surfaces	m²	510 SP (NSP)	Used when asphalt is removed from deck surface. Non-standard SP required to prevent damage to deck surface by cold planing equipment and to require removal of waterproofing membrane.	For detailing information and warrants, see Contract Design Estimating and Documentation Manual.
Hot-Mix HL	t	310 SP	Used as the base course over a waterproofing membrane. Specify HL 1, 2, 3, 4 or 8.	
Hot-Mix HL	t	310 SP	Used as the surface course for waterproofing and cathodic protection contracts and to pad the approach pavement on all contracts. Specify HL 1, 2, 3, 4 or 8.	
Dense Friction Course Mix	t	310 SP	Used as a surface course.	
Electrically Conductive Mix	t	SP (312)	Used with Cathodic Protection System.	
Traffic Control	lump sum	SP (520)	Used when traffic control and signing is the responsibility of the contractor.	
Temporary Concrete Barriers	lump sum	553 SP (504) SP (NSP)	Used when temporary concrete barriers are used for traffic protection. Where quantity is uncertain use lineal measurement instead of lump sum.	
Temporary Steel Beam Guide Rail	m	552	Used when temporary steel beam guide rail is used for traffic protection.	
Weld and Release Man Hole Frames and Grates	lump sum	SP (NSP)	Used when traffic is detoured over man holes or grates	
Cold Plane Concrete Pavement	m²	SP (NSP)	Required for the construction of permanent end treatment between bituminous overlay and existing concrete pavement.	

* NSP—Non-Standard Special Provision

**This item description must not be used verbatim. It is necessary to list separately excavation, conduit, ducts, wire, cable protection, and secondary supply facilities. In some cases, solar or wind power may be specified.

Existing structure drawings should be made available to the contractor so that unusual situations or difficulties can be anticipated. However, it is important that the drawings be reviewed by the Project Engineer to ensure that the drawings represent the "as-built" condition.

4.2/ Tender Items and Special Provisions

The tender items most frequently required in rehabilitation contracts and the conditions for their use are listed in Table 4. The item descriptions must be the same as those given in Table 4. Abbreviations are not permitted. The sequence of the tender items should be the same as the sequence of construction. Where it is known that the quantity of work is very small, it may be more appropriate to carry out the work under the extra work provisions of Form 100. The method for dealing with small quantity tender items is covered in Ministry Directive C-86.

Applicable specifications are identified in Table 4 by Ministry form numbers (e.g., 510, 904). The letters "SP" are shown to indicate that a special provision is required. The special provision may be a standard or a non-standard (job specific) special provision. Where a standard special provision is required, the number is given; a non-standard special provision is indicated by the abbreviation NSP in Table 4. Requirements for the preparation and use of special provisions are given in the Ministry's Structural Contract Handbook, Contract Design, Estimating and Documentation Manual and the Plan Quantity Payment supplement. Examples of non-standard special provisions are contained in the Supplement to this manual.

It is most important to note that in preparing contract documents, only those items, specifications and special provisions which apply to the work in hand are to be quoted.

4.3/ Quantities

The unit of measurement for each tender item is given in Table 4. The method of estimating quantitites for those items not bid as "lump sum" or "each" is given in Table 5. Production rates for estimating crew hours are given in Appendix D.

Table 5: Method of Estimating Quantities

Item	Unit	Method of Estimating Quantity
Scarifying	m^2	Measure area to be scarified from the drawings.
Removal of Concrete	crew hour	1/ For exposed concrete surfaces: a) Determine total area of spalls, delaminations and areas having a potential more negative than −0.35 V from the detailed condition survey (A_1 in m^2); b) Multiply (a) by 1.25 (A_2); c) Multiply (b) by 1.1 for each full year between time of survey and time of construction (A_3); d) Determine man-hours required (Appendix D) (M_1); e) Determine crew size after considering the total area to be removed, the deck size and the time available for removal (N_1); f) Calculate M_1/N_1 to give crew hours. 2/ For joints: a) Determine length and depth to be removed; b) Determine man-hours required (Appendix D), M_2; c) Establish crew size taking into account the quantity of concrete to be removed and the time available for joint installation (N_2); d) Calculate M_2/N_2 to give crew hours. 3/ On asphalt-covered decks: Follow procedure for exposed concrete surfaces except that no information is available on spalls and delaminations
Rental of Airhammer(s) (operated)	h	Calculate as $0.2(M_1 + M_2)$
Sandblasting Reinforcing Steel	m^2	Use value of A_3
Place Concrete Overlay	m^3	Calculate as $0.0012Ah + 0.04A_3$ where A = Area of overlay in m^2 h = nominal thickness of overlay plus the depth of scarifying (in mm) h will normally be: 48 mm for latex-modified concrete 58 mm for low- and normal-slump concrete. The method of calculating the quantity of concrete can be improved significantly where existing elevations are known and screed elevations are calculated.
Concrete Patches in Deck	m^3	For exposed concrete surface, calculate as $0.06A_3$.
Latex-Modified Shotcrete	m^3	a) Determine area of spalls and deteriorated areas from the detailed condition survey (A_4), b) Calculate as $0.15A_4$.
Reinforcing Steel	t	Calculate from the drawings.
Coated Reinforcing Steel	t	Calculate from the drawings.
Removal of Bituminous Pavement from Concrete Surfaces	m^2	*
Hot-Mix	t	*
Electrically Conductive Mix	t	*
Temporary Concrete Barriers	lump sum or m	*
Temporary Steel Beam Guide Rail	m	*
Cold Plane Concrete Pavement	m^2	*

*Calculated in accordance with the Contract Design, Estimating and Documentation Manual.

4.4/ Construction Schedule

Two methods are available to control the time of completion of a deck rehabilitation contract:

1/ Specify a number of working days.

2/ Specify a completion date.

The definition of a working day can be quite complex, especially where it is defined as a shift. Standard special provisions used by the Ministry to define working days are given in the supplement to this manual. The number of working days is established by the Working Day Committee. The amount of liquidated damages is also determined at this time.

The following factors affect the timing of the contract award date and duration of the contract.

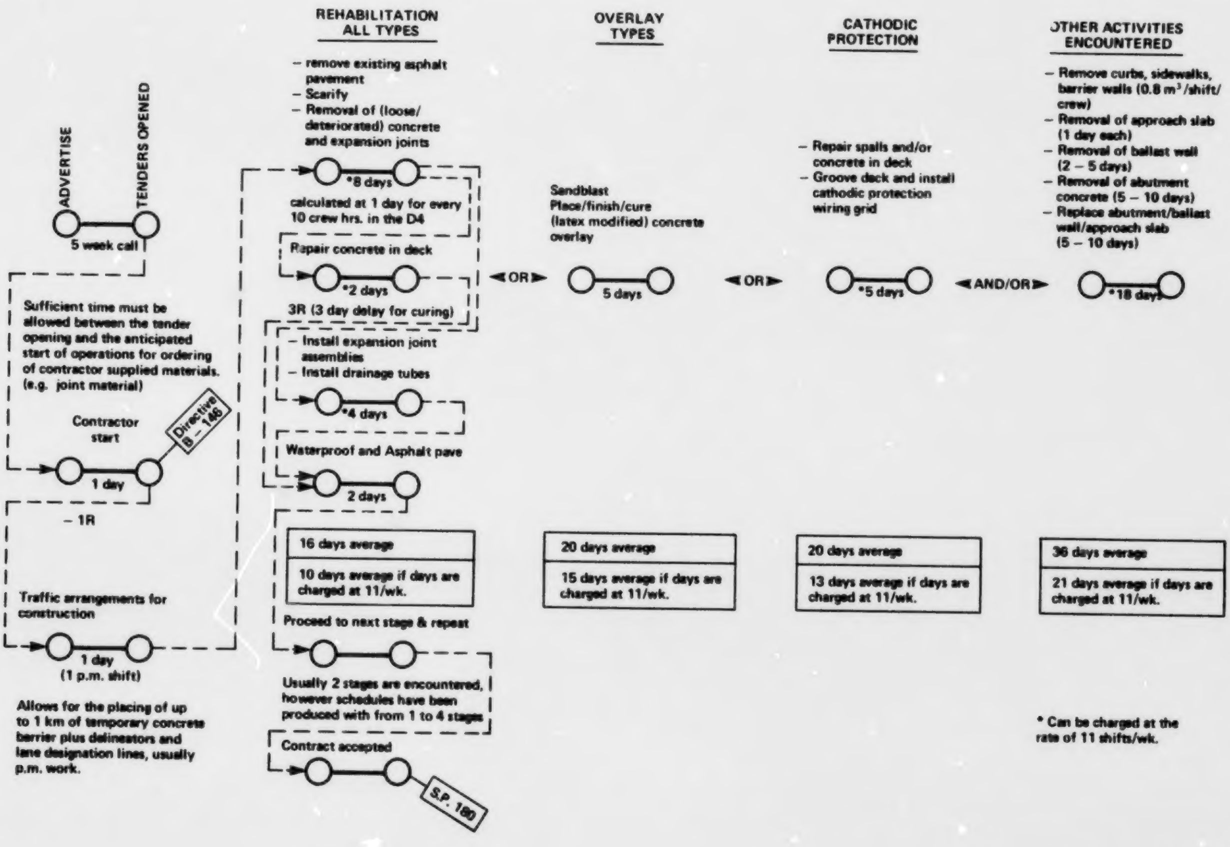
- Deck rehabilitation is normally carried out between April and October. Latex-modified overlays, which have stringent temperature restrictions, should be scheduled in the period May to September.
- Sufficient time must be allowed for items known to be in short supply, those requiring fabrication (e.g., joints and bearings), and the supply of equipment (e.g., temporary traffic signals). It is common to award contracts during the winter months while restricting the start of construction and working days to a specific date in spring.
- Where possible, the time of highest traffic volumes, special events and local festivals should be avoided.
- Noise by-laws may prevent night work in some locations.
- A critical path analysis is normally done to establish the duration of a project where traffic on major routes is affected.

A flowchart to assist in determining the duration of a contract is given in Figure 14. The chart is directed principally to work on freeways and gives the average length of time required for each major construction activity. It can also be useful for estimating the duration of contracts in other locations.

4.5/ Document Review

Following completion of the necessary reviews in the Regional Offices, as outlined in Section 2.8, the contract documents are forwarded to the Contract Management Office at least six weeks prior to the advertising date. The documents are subject to independent review. The review procedures and the process for resolving irregularities are described in detail in Ministry Directive C-144.

Figure 14/ Flow Chart for Major Construction Activities


REHABILITATION ALL TYPES
OVERLAY TYPES
CATHODIC PROTECTION
OTHER ACTIVITIES ENCOUNTERED
ADVERTISE
TENDERS OPENED
5 week call
Sufficient time must be allowed between the tender opening and the anticipated start of operations for ordering of contractor supplied materials. (e.g. joint material)
Contractor start
Directive B – 146
1 day
– 1R
Traffic arrangements for construction
1 day (1 p.m. shift)
Allows for the placing of up to 1 km of temporary concrete barrier plus delineators and lane designation lines, usually p.m. work.
– remove existing asphalt pavement
– Scarify
– Removal of (loose/deteriorated) concrete and expansion joints
*8 days
calculated at 1 day for every 10 crew hrs. in the D4
Repair concrete in deck
*2 days
3R (3 day delay for curing)
– Install expansion joint assemblies
– Install drainage tubes
*4 days
Waterproof and Asphalt pave
2 days
16 days average
10 days average if days are charged at 11/wk.
Proceed to next stage & repeat
Usually 2 stages are encountered, however schedules have been produced with from 1 to 4 stages
Contract accepted
S.P. 180
OR
Sandblast
Place/finish/cure
(latex modified) concrete overlay
5 days
20 days average
15 days average if days are charged at 11/wk.
OR
– Repair spalls and/or concrete in deck
– Groove deck and install cathodic protection wiring grid
*5 days
20 days average
13 days average if days are charged at 11/wk.
AND/OR
– Remove curbs, sidewalks, barrier walls (0.8 m³/shift/crew)
– Removal of approach slab (1 day each)
– Removal of ballast wall (2 – 5 days)
– Removal of abutment concrete (5 – 10 days)
– Replace abutment/ballast wall/approach slab (5 – 10 days)
*18 days
36 days average
21 days average if days are charged at 11/wk.

* Can be charged at the rate of 11 shifts/wk.

5/ REFERENCE PUBLICATIONS

5.1/ Ministry Publications

1/ Structural Manual
2/ Structural Contract Handbook
3/ Contract Design Estimating and Documentation Manual
4/ Plan Quantity Payment, Supplement to Contract Design Estimating and Documentation Manual
5/ Manual for Bridge Deck Waterproofing
6/ Highway Engineering Standard Drawings Road Barriers and Drainage – Book 1
7/ Highway Engineering Standard Drawings Electrical – Book 2
8/ Highway Engineering Standard Drawings Structural – Book 3
9/ General Conditions and Standard Specifications
10/ Ontario Highway Bridge Design Code, Second Edition (1983)
11/ MTC Designated Source List
12/ Traffic Control Manual for Roadway Work Operations
13/ Manning, D.G., and Ryell, J., "A Strategy for the Rehabilitation of Concrete Bridge Decks", ME-79-02(1979). Also published in RTAC Forum, Vol. 3, No. 4, pp 75-82(1981).
14/ Fromm, H.J., "Cathodic Protection for Concrete Bridge Deck Restoration", SP-81-01.
15/ Construction Manual
16/ Provincial Roads Directive B-118 "Bridge Deck Rehabilitation"
17/ Provincial Highways Directive B-146 "Rehabilitation Contracts Freeways"
18/ Provincial Roads Directive C-86 "Small Quantity Tender Items"
19/ Provincial Highways Directive C-141 "Acceptance/ Rejection Guidelines for Bridge Deck Waterproofing Membrane Thickness"
20/ Provincial Highways Directive C-144 "Project Documents Review"

5.2/ Other Publications

1/ "Durability of Concrete Bridge Decks", NCHRP Synthesis of Highway Practice, NO. 57, Transportation Research Board (1979).

APPENDIX D/ Production Rates for Concrete Removal

Location	Production Rate
Deck Surface	0.5 m^2/man-hour
Deck Soffit and Vertical Surfaces	0.2 m^2/man-hour
Joint Area Removal	
$\leq$ 150 mm deep (Shallow)	0.6 m/crew-hour*
> 150 mm deep (Deep)	0.3 m/crew-hour*

*crew assumed to be five labourers with four hammers (one crew member engaged in clean up).

Number/
Numéro

3

Ontario

Ministry of
Transportation and
Communications

Research and
Development
Branch

Bridge Deck Rehabilitation Manual

Supplement:
Special Provisions and Reference Contracts

SP-018

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Abstract:
This Supplement contains a list of standard special provisions, examples of non-standard provisions and references to sample contracts.

The standard special provisions which may be required in bridge deck rehabilitation contracts are identified in this Supplement.

The non-standard special provisions are given as samples, not to be used verbatim. Being job-specific, they are to be used where applicable.

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1/ INTRODUCTION

This Supplement contains a list of standard special provisions, examples of non-standard special provisions and references to sample contracts.

The standard special provisions which may be required in bridge deck rehabilitation contracts are listed by number in Table 4 of Part Two of the Bridge Deck Rehabilitation Manual. They are also identified in this Supplement.

The non-standard special provisions are not intended to be used verbatim but are given as samples. Most have been extracted from recent contracts. Before using any non-standard special provision, the user must verify that it is applicable. In most cases, changes will be required because, by their very nature, non-standard special provisions are job specific. Footnotes are given where information must be added to the special provisions or where explanation of their use is needed.

It is envisaged that much of the material in this supplement will eventually be incorporated in specifications or standard special provisions, at which time the Supplement will be withdrawn.

2/ NON-STANDARD SPECIAL PROVISIONS

2.1/ Removal of Concrete

The first sentence, paragraph 2 of subsection 930.07.02.04 of Form 930 is amended in that the work unit shall consist of ————* labourers, an air compressor with a minimum capacity of ————** m^3/min, a minimum of ————* air hammers (———* chipping, ————* jack) complete with suitable breaker bits, hoses, towing unit, concrete saw and other equipment necessary to do the removal work.

---

*Indicate the number of labourers and air hammers required.

**Indicate the required minimum capacity for compressor required.

This special provision is used to amend Form 930 if the crew size is not suitable for a specific project.

2.2/ Removal of Concrete from Deck Soffit and Substructure

This special provision covers the requirements for the removal of concrete from the deck soffit and substructure including the disposal of the resultant debris. Areas of removal shall be defined by neat edge to a minimum depth of 25 mm.

Equipment

Chipping Hammers -- shall be 7.0 kg maximum
Jack Hammers -- shall be 14.0 kg maximum

Construction

The Contractor shall supply a work unit to remove and dispose of existing concrete from areas of the deck soffit and substructure requiring restoration.

The work unit shall consist of ________* labourers, an air compressor with a minimum capacity of ____** m^3/min, a minimum of _________* air hammers (______* chipping, ______* jack) complete with suitable breaker bits, hoses, towing unit, and other equipment necessary to do the removal work. As part of the work unit the contractor shall supply all necessary equipment and operators to do the disposal work including arranging for the disposition of the resultant debris at locations outside the right of way.

All loose and unsound concrete shall be removed from the deck soffit and substructure as designated by the Engineer. Care shall be taken not to damage, cut or loosen reinforcing bars.

Jack hammers shall be used for the removal of concrete to the reinforcing bars.

---

*Indicate the number of labourers and air hammers required.
**Indicate the required minimum capacity for compressor required.

Chipping hammers shall be used for the removal of concrete around and beneath reinforcing bars.

Chipping shall extend along all reinforcing bars to the point where the exposed bars are free of heavy rust. Concrete covering bars at the edges of spalls shall be sounded by the Engineer for local delaminations before chipping is completed.

Where the bond between concrete and reinforcing steel is broken; or where more than half of the perimeter of the bar is exposed, the concrete surrounding the bars shall be removed to a depth of 25 mm below the bar.

In large areas of concrete removal, where bars are completely exposed, bars shall be retied at each intersection point.

Measurement for Payment

The measurement for removal of concrete is based on the number of crew hours that the complete "work unit" is in effective operation.

Basis of Payment

Payment at the contract price for this tender item shall be full compensation for all labour, equipment and material required to do the work and shall include disposal and the use of disposal sites outside the right-of-way.

This special provision is used when concrete must be removed from the soffit or substructure.

When setting the crew size, input from the Construction Office may be required.

2.3/ Removal of Structure

This special provision covers the requirements for carrying out the following work, all as shown on the contract drawings.

1/ To remove:
   a) Steel handrails and concrete posts;
   b) Portion of concrete sidewalk;
   c) Concrete curb and portion of deck under curb.
2/ To sawcut concrete.
3/ To clean and straighten existing reinforcing steel.
4/ To make good with 30 MPa concrete, areas that require rebuilding.
5/ To grind concrete.

The air hammer used for removal of concrete shall not exceed 14 kg.

Drawings of the existing structure provided by the Ministry show approximate dimensions.

The steel handrails will remain the property of the MTC and shall be carefully dismantled and delivered to the MTC Patrol Yard at ________*.

Basis of Payment

Payment at the contract price for this tender item shall be full compensation for all labour, equipment and material required to carry out the work.

---

*Indicate the location of a suitable MTC Patrol Yard if handrails are to be salvaged.

A special provision of this type is used when portions of the structure to be removed can be clearly defined, e.g., curbs, sidewalks. However, it should not be used when removing a portion of the ballast wall (which should be done on a crew hour basis).

2.4/ Supply and Install Joint Assemblies

This special provision covers the requirements for supplying and installing joint assemblies including the preparation of the recess, modifying reinforcement and supplying, placing and curing concrete and supplying and placing reinforcing steel.

Concrete removal shall be carried out as a separate tender item.

The removal of existing styrofoam in the area of the joints shall be carried out as Extra Work in accordance with Form 103-3.

Construction

Prior to placement of epoxy-coated reinforcing steel in the joint recess, all concrete surfaces against which new concrete is to be placed shall be thoroughly cleaned by sandblasting. The sandblast shall remove all scale and corrosion deposits from exposed reinforcing steel. The sand shall be removed from the joint recess by air blasting. Sandblasting will not be permitted unless the existing concrete is surface dry at the time the operation commences. All dust and loose material shall be removed from the prepared surface of the existing concrete by oil-free compressed air before application of the cement paste. The existing concrete surface shall be damp at the time of application of the cement paste. A thin coating of cement paste shall be brushed onto the prepared surface. All vertical and horizontal surfaces against which the concrete is to be placed shall receive a thorough, even coating with no excess of cement paste in any area.

The concrete shall be placed in the joint recess, adequately consolidated and hand-finished with a wood float.

The expansion joint gap shall be air cleaned prior to the installation of the seal.

The seal shall be installed in one continuous length at the end of the last stage of the work.

Basis of Payment

Subsection 920.15.01 of Form 920 is amended as follows: Payment at the contract price shall be compensation in full for all labour, equipment and material required to complete the work including any necessary welding, supplying and placing reinforcing steel and concrete, placing and removing formwork and sandblasting.

2.5/ Modification of Deck Expansion Joints

As part of the work and included in the price bid for this tender item, the Contractor shall install the expansion joints at the curb or sidewalk as shown on the contract drawings including sawcutting, concrete removal, sandblasting and supply and place concrete.

A special provision of this type is used when the existing joint is to be modified rather than replaced.

2.6/ Concrete in Ballast Wall

This special provision covers the requirements for supplying and placing concrete in the abutment ballast wall to the limits shown on the contract drawings. This work will include the preparation of existing concrete surfaces (including the application of cement paste), cleaning and straightening existing reinforcing steel, supplying and placing concrete, supplying and placing additional reinforcing steel, finishing and curing of concrete.

Payment at the contract price bid for the item shall be full compensation for all labour, equipment and material required to do the work.

2.7/ Concrete in Approach Slabs

This special provision covers the requirements for supplying and placing concrete in approach slab to the limits shown on the contract drawings. This work will include the preparation of existing concrete surfaces (including the application of cement paste), cleaning and straightening existing reinforcing steel, supplying and placing additional reinforcing steel, finishing and curing concrete.

Payment at the contract price for this item shall be full compensation for all labour, equipment and material required to do the work.

2.8/ Deck Drains

As part of the work for this tender item, the Contractor shall remove the existing deck drains to 50 mm below the concrete surface, plug the drains with concrete, and make good the surrounding area, with 30 MPa concrete.

Prior to placing concrete, the areas against which new concrete will be placed shall be sandblasted, moistened and coated with a cement paste.

The air hammers used for the removal of concrete shall not exceed 14 kg.

Payment at the contract price shall be full compensation for all labour, equipment and material required to install the 150 mm diameter drains and to remove and replace the concrete in the curb as required for the installation.

A special provision of this type is used where new deck drains are to be installed.

2.9/ Supply and Install Bearings

This special provision covers the requirements for carrying out the following work, all as shown on the contract drawings.

1/ Jack the structure at both abutments.

2/ Remove the existing bearings, brush clean the steel plates and clean bearing seats.

3/ Install new bearings as shown on the contract drawings.

Bridge Jacking

The jacking operations shall be carried out using jacks with the minimum capacity and placed at locations shown on the drawings.

The lift of 12 mm shall be carried out in one synchronized jacking operation. At no time during the lift shall the difference between any jacking point be more than 3 mm. The maximum permissible lift shall be 6 mm greater than the required lift.

After the bearings are installed, the deck shall be lowered in a synchronized operation, while maintaining the maximum allowable difference between jacking points of 3 mm.

The jacking operation, installation of bearings and lowering the bridge on to the new bearings shall be completed in one working day.

A proposal on the jacking operation shall be submitted to the Engineer for his approval 14 days before the jacking operation is to commence.

Payment at the contract price for this tender item shall be full compensation for all labour, equipment and material required to do the work.

This sample special provision was used in a recent contract for the replacement of bearings.

2.10/ Supply and Install Drainage Tubes in Deck

Payment at the contract price for this tender item shall be full compensation for all labour, equipment and material required to supply and install drainage tubes in the deck as shown on the contract drawings.

2.11/ Access to Work Area -- Example 1

The Contractor shall provide access to the work area for all work and inspection required in the contract, by supplying, erecting, maintaining and dismantling the work platform.

Payment at the contract price for this tender item shall be full compensation for all labour, equipment and material to provide access to the work area.

A special provision of this type should be used when a work platform is required to carry out rehabilitation work to the soffit or substructure or if it is thought that the cost of such access might be duplicated due to multiple operations by separate sub-contractors.

This example would be used when the requirement is to provide access only.

2.12/ Access to Work Area -- Example 2

The contractor shall provide access to the work area for all work and inspection required in the contract, by supplying erecting, maintaining and dismantling the work platform.

The work platform must be portable when removing concrete or making repairs to the soffit of the structure over Hwy *. The times during which the portable work platform can be in place are described under operational constraints. At other times the portable work platform shall be removed and stored away from the travelled portion of the roadway. When working over or adjacent to the travelled portion of the roadway, the contractor shall provide protection, to the satisfaction of the Engineer, to prevent any debris from falling onto the travelled portion of the roadway during concrete removal or structure repairs.

Payment at the contract price for this tender item shall be full compensation for all labour, equipment and material to provide access to the work site and protection from falling debris.

See general footnote for Example 1.

This example is used when the requirements are to provide access, a portable work platform and protection from falling debris.

* Insert highway number.

2.13/ Temporary Support

Subsection 919.10 of Form 919 is ammended in that payment at the contract price for this tender item shall be full compensation for all labour, equipment and material required to supply, erect, maintain, dismantle and remove all necessary falsework and/or other means of support required to support the ends of the girders during the repair of the pier caps and columns. The support shall be tight against the bottom of the girder at all times by jacking, if necessary, to release any load from the girder to the pier.

A special provision of this type is used when the bearings are being replaced or when repairs are being made to the abutment or pier bearing seat and it is necessary to support the superstructure during the repair.

2.14/ Concrete Patches in Deck

This special provision covers the requirements for sawcutting to delineate removal areas, sandblasting, supplying, placing, finishing and curing of concrete patches in the deck. Concrete removal shall be carried out as a separate tender item. Areas of removal shall be delineated by a sawcut 25 mm deep.

Materials

Cement --shall meet the requirements of Form 1301.

Concrete -- shall meet the requirements of Form 1350 and shall have a nominal minimum 28 d strength of 30 MPa. The nominal maximum size aggregate shall be 13.2 mm.

Burlap -- shall meet the requirements of Form 1306.

Polyethylene Film -- shall be opaque, white pigmented, shall conform to the requirements of Form 1305, and shall not be less than 100 μm thick.

Sand for Sandblasting -- shall be angular or subangular silica sand having a minimum size of 425 μm.

Bonding Grout -- for bonding the concrete patches to existing concrete shall consist of equal parts by mass of normal Portland cement and sand, mixed with sufficient water to form a stiff mixture. The consistency of the mixture shall be such that it can be applied with a stiff brush to the existing concrete in a thin, even coating that will not run or puddle. The constituent materials shall comply with the requirements of Form 1350.

Equipment

Air Compressor - Air Blasting -- the air compressor shall have a minimum capacity of 3.5 m^3/min. The compressed air shall be free of oil.

Air Compressor - Sandblasting -- Each nozzle shall be supplied by a single compressor having a capacity of not less than 8.5 m^3/min. The air pressure at the pot shall be not less than 690 kPa and not less than 620 kPa at the nozzle. Hoses shall not be less than 40 mm I.D. The air compressor shall be supplied with suitable pressure gauges to confirm the above.

Stationary Mixers -- shall be suitable for mixing the mortar bonding grout.

Construction

Sandblasting -- Not more than 24 hours before placement of the concrete begins, all concrete surfaces against which the concrete is to be placed shall be thoroughly cleaned by sandblasting. The sandblasting shall be of such an extent to expose the coarse aggregate and remove all dirt and other foreign material. The sandblast shall remove all scale and corrosion deposits from exposed reinforcing steel. All sand shall be removed from the deck and adjacent surfaces. Sandblasting shall not be permitted unless the deck concrete is surface dry at the time the operation commences. Construction equipment shall not be parked or travel directly on exposed reinforcing steel.

Placing Patch Material

All dust and loose material shall be removed from the prepared surface by oil-free compressed air before application of the bonding grout. The areas to be patched shall be damp at the time the bonding grout is applied. A thin coating of bonding grout shall be brushed onto the prepared surface. All surfaces against which the patch material is to be placed shall receive a thorough, even coating with no excess of grout in any area. Bonding grout not used within 30 minutes after mixing shall be discarded.

The concrete shall be placed in the patch areas, adequately consolidated, and hand finished with a wood float.

Curing Concrete -- Two layers of wet burlap shall be placed on the surface of the concrete as soon as the surface will support it without deformation. Burlap shall be thoroughly soaked for 24 hours prior to placing. A layer of polyethylene film shall be placed immediately on the wet burlap.

The concrete shall be cured using the wet burlap covered with polyethylene film for a minimum 72 hours.

Measurement for Payment

Measurement for placing the concrete in patches shall be in cubic metres and will be based on the contractors delivery ticket. The quantity of bonding grout will not be measured.

Basis of Payment

Payment at the contract price for this tender item shall be full compensation for all labour, equipment and material required to prepare the surface, supply, place, finish, and cure concrete.

A special provision of this type is used when the deck is patched prior to waterproofing and paving or prior to the application of a cathodic protection system.

The removal of concrete prior to patching is carried out in accordance with Form 930.07.02.04 as a separate tender item.

2.15/ Removal of Bituminous Pavement from Concrete Surfaces -- Example 1

As part of the work and at the price bid for this tender item, the deck surface shall be cleaned of any material which might act as an electrical insulator such as tack coat, waterproofing or hot-mix.

Rotary cold milling equipment is permitted for the removal of bituminous pavement from bridge decks. However, should the cutting teeth of the milling equipment come in contact with the concrete surface of the bridge, it will be necessary for the Contractor to take such remedial action as necessary to ensure that the concrete surface is of acceptable smoothness. Prior to the application of the cathodic protection hardware, any concrete damaged by milling shall be restored to a texture at least as smooth as a bush hammered concrete surface.

In cases where the Contractor's asphalt removal operation creates depressions in the deck which will cause ponding or non-draining areas on the deck, the Contractor shall place concrete patches in accordance with Ministry procedures.

The Contractor is responsible to carry out such remedial action as may be required to restore the deck damaged in the cold milling operation and no separate payments will be made, as all costs shall be deemed to be included in the asphalt removal item.

This tender item is normally the responsibility of the Planning and Design Section but the Project Engineer should ensure that this special provision is included with the above mentioned tender item if the deck is to be cathodically protected.

2.16/ Removal of Bituminous Pavement from Concrete Surfaces -- Example 2

As part of the work and at the price bid for this tender item, the Contractor shall remove all waterproofing materials.

Rotary cold milling equipment is permitted for the removal of bituminous pavement from bridge decks. However, should the cutting teeth of the milling equipment come in contact with the concrete surface of the bridge, it will be necessary for the Contractor to take such remedial action as necessary to ensure that the concrete surface is of acceptable smoothness to allow for waterproofing. Prior to the waterproofing operation any concrete damaged by milling shall be restored to a texture at least as smooth as a bush hammered concrete surface.

In cases where the Contractor's asphalt removal operation creates depressions in the deck which will cause ponding of the waterproofing material, or nondraining areas on the deck, the Contractor shall place concrete or mastic patches in accordance with Ministry procedures.

The Contractor is responsible to carry out such remedial action as may be required to restore the deck damaged in the cold milling operation and no separate payments will be made, as all costs shall be deemed to be included in the asphalt removal item.

The temporary ramps to the exposed concrete surface of the bridge deck shall be constructed by cold planing as per typical sections in the drawings, as part of this item.

This tender item, is normally the responsibility of the Planning and Design Section but the Project Engineer should ensure that this special provision is included with the above mentioned tender item if the deck is to be waterproofed.

2.17/ Embedded Work in Structure for Cathodic Protection

This special provision covers the supply and installation of cathodic protection materials embedded in the bridge deck.

Materials

- Anodes
  Anodes shall be DURCO Pancake Bridge Deck Anodes Type I. A lead wire shall be leaded in a hole in the anode and the hole sealed with a plastic or asphaltic compound. The lead wire shall be installed by the anode manufacturer.

- Voltage Probes
  Voltage probes shall be fabricated from a square bar of graphite. Each probe shall not be less than 35 x 35 x 150 mm. A wire shall be fitted into a hole in one end of the probe with a mechanical seal and the hole filled with a plastic or asphaltic compound. The wire shall be installed by the probe fabricator.

- Half-Cells
  Half-cells shall be of the zinc-zinc sulphate type not less than 40 mm dia x 100 mm long nor more than 50 mm dia x 125 mm long. A lead wire shall be cast in the zinc.

  Approved suppliers for anodes, voltage probes and half-cells:
  Corrosion Service Co. Ltd., Toronto
  Interprovincial Corrosion Control Ltd., Burlington.

- Wires
  All wires shall be stranded copper, type TWU insulated. The size and colour of insulation shall be as follows:
  - rebar ground bus -- #6 white
  - rebar ground connecting wires -- #10 white
  - anode bus -- #6 black
  - anode connecting wires -- #10 black*
  - probe lead wires -- #10 red (or approved colour change)*
  - half-cell lead wires -- #10 green (or approved colour change)*

*Length of wire installed by manufacturer or fabricator shall be sufficient to reach the curb as indicated on the plans.

- In-line Crimp Connectors

  In-line crimp connectors for connection of #10 AWG cables (at curb) for probes and half-cells shall be butt type sleeves complete with insulators.

  Approved manufacturers:

  Thomas & Betts Cat. No. 2RC10
  3M Cat. No. D-42-401.

- Thermite Weld Connectors

  Thermite weld connectors for connection of #10 AWG anode or rebar ground leads to #6 AWG feeder or bus and for connection of #10 AWG wire to reinforcing steel shall be "Cadweld", as manufactured by Erico Inc., Toronto or approved equal.

- Silicone Seal

  Silicone seal shall be Canadian General Electric RTV-108 or approved equal.

- Epoxy

  Epoxy paste shall consist of fibres or fine mineral filler added to epoxy resin and curing agent to give a paste-like consistency. As an alternative, a thick epoxy such as Chemque No. QT-1234 may be used without a thickening material.

- Mortar

  Mortar shall be air entrained and shall consist of one part normal Portland cement and three parts sand by weight with sufficient water to form a stiff mixture in accordance with the requirement of Form 1350.

- Concrete

  Concrete shall be 30 MPa class in accordance with the requirements of Form 1350.

- Tape

  Electrical vinyl tape shall meet the requirements of Form 2495 and shall be suitable for cold weather application (3M #88 or equal).

- Conduit

  Conduit and accessories shall be rigid PVC type and shall meet the requirements of Form 2497.

Equipment

- Core drills -- 100 mm and 150 mm diameter
- Concrete saw with dry, abrasive blades
- Compressor with 14 kg jackhammer and blow tube
- Acetylene cutting torch
- Cadweld molds and supplies
- Pachometer (cover meter)
- High impedance a.c. ohmmeter with minimum 50 V output

Construction

- Sequence

  The work described in this special provision shall not commence until bridge deck repairs have been completed, fully or in sections, as approved by the Engineer.

- Deck Entry

  A deck entry hole of 100 mm diameter shall be drilled through the deck in the locations indicated in the contract drawings. A 75 mm diameter PVC conduit end bell and support mechanism shall be installed and grouted in place as indicated.

- Anodes

  The base and sides of the anodes shall be given two coats of epoxy resin applied not less than 24 h before they are placed in the structure. Protective tape shall be applied to the top face and left in place until paving operations commence.

  Anode locations shall be accurately marked on the deck as indicated in the drawings. A pachometer shall be used to determine reinforcing bar locations and the final anode location may be moved up to 150 mm in any direction such that the minimum number of reinforcing bars will have to be cut in making the recess. Where the concrete cover on the reinforcing bars is greater than 50 mm, the anode recesses do not require the cutting of reinforcing bars. Anode recesses shall be cut by either of the following methods.

- Use a core drill and remove the concrete by use of a jackhammer. Cut reinforcing steel flush with the hole walls and continue the operation to obtain the full 50 mm depth with as smooth a bottom as practical.

- Use a concrete saw to form a square as indicated in the drawings and remove the concrete by use of a jackhammer. Cut reinforcing steel and complete as per above.

Immediately upon completion of the anode recess, the ends of any cut reinforcing bars shall be coated with a thick layer of epoxy. The anode wire slot shall then be cut from the anode recess to the curb as indicated in the drawings.

A 12 mm thick bed of epoxy shall be placed in the anode recess. The anode shall be placed such that the lead cable feeds directly into the cable slot and adjusted such that the anode surface is flush with the concrete deck. The anode shall be supported by insulating spacers to prevent settlement in the epoxy paste. After the epoxy bed has set, all cavities around the anode shall be filled with mortar flush with the deck. If a concrete saw was used to form the recess, all saw cuts beyond recess shall be sealed with epoxy, flush with the deck.

The anode lead wire shall be set in the slot and the slot shall be sealed with epoxy flush with the deck.

The resistance between the anode lead wire, at the curb, and the rebar ground bus shall be measured with an a.c. ohmmeter. If the indicated resistance is less than 50 ohms, a short circuit may exist. In this case, the anode shall be removed and reset, with reinforcing bars reinsulated with epoxy. The resistance tests shall be done in the presence of the Engineer prior to connection of the lead wires to the feeder wires.

- Rebar Ground Connections

Rebar ground locations shall be marked on the deck as indicated in the drawings. A pachometer shall be used to indicate the closest reinforcing bar. A 150 mm core drill shall be used to expose the bar. The bar shall be cleaned free of corrosion products to accept the thermite weld connection. The rebar ground wire slot shall be cut between the recess and the curb as indicated in the drawings. The rebar ground wire shall be run in the slot and thermite welded to the bar. When the weld has cooled, a 5 mm thick layer of silicone seal shall be applied to the entire weld area of the bar and allowed to set. The recess shall be filled with concrete flush with the deck. The rebar ground wire slot shall be filled with epoxy flush with the deck.

- Probes

Probe locations shall be marked on the deck as indicated in the drawings. A pachometer shall be used to indicate the location of reinforcing bars and the probe location shall be marked midway between two bars. A recess and lead wire slot in the concrete shall be made as indicated in the drawings. A cement grout bed shall be placed and the top of the probe adjusted flush with the deck. Mortar shall then be used to fill all voids flush with the deck. The lead wire slot shall be filled with epoxy flush with the deck. The probe shall be covered with adhesive tape until paving operations commence.

- Half-cells

Half-cells locations shall be marked on the deck as indicated in the drawings. A pachometer shall be used to locate the nearest reinforcing bar. A recess and lead wire slot shall be made in the concrete deck as indicated in the drawings. The ground connection to the reinforcing bar shall be made first. The bar shall be cleaned free of corrosion products to accept the thermite weld connection. The ground lead shall be run in the slot and thermite welded to the bar. When the weld is cool, the entire weld and reinforcing bar in the area of the weld shall be coated with a 5 mm thick coat of silicone seal.

The remainder of the exposed reinforcing bar shall be coated with a 5 mm thich coat of mortar.

The half-cell shall be placed against the grout coating with the centre of the half-cell level with the centre of the rebar. If this results in the half-cell being less than 5 mm below the deck surface, the half-cell shall be lowered to provide a minimum of 5 mm cover. The half-cell lead wire shall be set in the slot and the slot shall be sealed with epoxy flush with the deck.

The saw cuts of the half-cell recess shall be filled with epoxy. After hardening of the epoxy, all voids in the half-cell recess shall be filled with concrete, level with the deck.

- Connections at Curb

Connections of lead wires to buses or lead wire extensions along the curb are required as follows:

anodes: #10 (black) lead to #6 (black) anode bus,
rebar ground: #10 (white) lead to #6 (white) rebar ground bus,
probes: #10 (red) lead to #10 (red) lead wire extension,
half-cells: #10 (green) lead to #10 (green) lead wire extension
#10 (white) lead to #10 (white) half-cell ground extension.

All buses and extension wire shall be of sufficient length for termination in the control panel without splicing.

All connections of #10 cable to #6 cable (anodes and rebar grounds) shall be made with thermite weld connections. The connections shall be insulated with a double half-lap of electrical vinyl tape and made waterproof with a 5 mm thich application of silicone seal.

All connections of #10 cable to #10 cable (probes and half-cells) shall be made with compression sleeve connectors. The connections shall be soldered after crimpring and insulated with a sleeve. A double half-lap layer of electrical vinyl tape shall be applied over the insulating sleeve and the connection shall be made waterproof with a 5 mm thick application of silicone seal.

The free end of each wire shall be numbered at the control panel with the number of the component as shown on the drawings.

- Wires along Curb

  All cables shall be bundled, along the edge of the curb, using nylon cable ties. The cables shall be tied where cable leads join the cable bundle and at 3 m maximum centres. The cable ties shall be fastened to the deck using an insulated anchorage device.

  The wire bundle shall be completely covered by a fillet strip of formed air entrained concrete as indicated in the drawings. Where the deck drains are located the curb side of the filler strip, drainage shall be provided as shown on the drawings. The deck entry shall be sealed with a silicone plug not less than 50 mm thick, level with the deck surface and covered by continuation of the formed filler strip.

- Final Deck Preparations

  The deck surface shall be checked for exposed metal such as tie wires or reinforcing steel which is electrically continuous with the deck reinforcing steel. Any such metal shall be insulated with two coats of epoxy resin.

Shop Drawings

The Contractor shall submit four copies of shop drawings which include the following information:

- detailed Bill of Materials including model numbers and sizes,
- wiring diagram.

Shop drawings will be given approval for construction if found to be acceptable or will be marked with corrections if found to be unacceptable. The Contractor shall allow a period of 15 working days from the time of submission of the shop drawings for initial and each subsequent submission where corrections are required, until final approval is issued.

Payment

Payment at the contract price shall be full compensation for all labour, equipment and materials required to do the work as specified herein.

2.18/ Surface Work on Structure for Cathodic Protection

This special provision covers the supply and installation of surface-mounted cathodic protection materials on the structure.

Materials

- Conduit and Fittings

  Conduit and fittings, of the type and size indicated in the contract drawings, shall meet the requirements of Form 2497.

- Wiring

  Wiring shall be stranded copper #12 AWG type TWH.

- Electrical Equipment Support System

  The structural steel frame for the electrical equipment support system shall be fabricated, supplied and erected as shown on the drawings and in accordance with Form 906. All structural steel shall conform with CSA G40.21M, Grade 300W. Form 906.02 is amended in that all bolted connections shall be made with 22 mm diameter high strength bolts conforming to ASTM Specification A325, Type 1, unless noted otherwise. The frame shall be painted grey in accordance with Form 1704.

- Supply Control Cabinet

  The supply control cabinet shall be type EEMAC 4X panel enclosure (Hammond Cat. No. 1418N4SSB6) complete with inner panel for mounting the following equipment:

  - One 2-P, 50A, 240 V a.c. main circuit breaker (CGE Cat. No. TEB122050
  - Two 1-P, 15A 120 V a.c. branch circuit breakers (CGE Cat. No. TEB111015)
  - One solid neutral assembly (Square D Cat. No. S-100-SN)
  - One ground connector (ETLIN Cat. No. EU70)
  - No. 6 AWG RW90 copper wire.

- Control Panel

  The control panel box shall be stainless steel, Hammond Cat. No. 1418N4SSE10 or approved equal.

The instrument panel shall be 2 mm thick construction grade steel, primed and enameled (white) and fitted with stand-offs not less than 100 mm long.

Terminal strips shall be of the insulated barrier type, Cinch-Jones Cat. No. 12-540 or approved equal.

On-off switch shall be JBT Cat. No. 4222S or approved equal.

5-way binding posts shall be Superior Cat. No. DF31 RD (red) or DF31 BC (black) or approved equal.

Voltmeter shall be CGE Cat. No. L531 MTMT or approved equal.

Ammeter shall be CGE Cat. No. L530 LSLS or approved equal.

- Rectifier

The rectifier unit shall be a standard auto-volt rectifier, designed for cathodic protection installations, with the following features:

Cabinet	-- stainless steel with padlock hasp, wall mount
Line	-- 120 V a.c., 60 Hz
Output	-- 0-8 V d.c. continuously variable from autotransformer 4A max.)
Bridge	-- centre tap, single phase, full wave
Rectifier stack	-- silicon
Protection	-- Lightning protection on input and output
Metering	-- panel-mounted voltmeter and ammeter

The rectifier shall be Goodall #TPAYCA84GKNS or approved equal.

Construction

- Equipment Mounting

Equipment, conduit systems and support system shall be arranged and installed plumb in the location indicated in the drawings. Each equipment enclosure and each conduit strap shall be installed with expandable metal concrete insert anchors, stainless steel bolts and stainless steel flat washers and lock washers.

- Control Panel Assembly

The control panel shall be shop assembled in a neat and symmetrical manner. The panel shall be removable from the front of the enclosure. All binding posts shall be identified by adhesive lettering sprayed with plastic.

All internal panel wiring shall be with #12 AWG stranded copper cable, type TWH.

- Wiring

Each anode feeder cable (#6 black) from the bridge deck shall be connected to the designated terminal on the terminal strip. Two shorted terminals shall be used for connection of the rebar ground buses (#6 white) which shall be independent of equipment ground.

Each probe lead cable (#10 red) shall be connected to the designated terminal on the terminal strip.

Each half-cell lead cable (#10 green) shall be connected to the panel jacks labelled for half-cells with corresponding numbers. Each half-cell ground cable (#10 white) shall be left unconnected and insulated with an insulated spring connector.

A green cable shall be run from one jack (half-cell H2) to the rectifier assembly. An accompanying white cable from the half-cell (H2) ground shall be run to the rectifier assembly. These cables shall be connected to the half-cell terminals and structure terminal in the rectifier assembly, respectively.

The positive (+) and negative (-) terminals of the control panel shall be connected to the matching terminals in the rectifier assembly using black and white cables respectively.

Feeders from the circuit breakers to the duplex outlet in the control panel and to the rectifier assembly shall be black and white.

- Grounding

  A #6 AWG type TWH (green) ground wire shall be run in conduit between each electrical enclosure and connected securely. Sufficient length for the installation of ground rods shall be left at the supply cabinet.

Shop Drawings

The Contractor shall submit four copies of shop drawings which include the following information:

- detailed Bill of Materials including model numbers and sizes,
- detailed drawing of equipment panel layout,
- wiring diagram.

Shop drawings will be given approval for construction if found to be acceptable or will be marked with corrections if found to be unacceptable. The Contractor shall allow a period of 15 calendar days from the time of submission for initial and each subsequent submission where corrections are required, until final approval is issued.

Payment

Payment at the contract price shall be full compensation for all labour, equipment and materials required to do the work as specified herein.

2.19/ Latex-Modified Shotcrete

At the time of printing this Supplement, a standard special provision for latex-modified shotcrete was being prepared by the Concrete Section of the Engineering Materials Office. The user is requested to contact the Concrete Section to obtain the most up-to-date copy of the special provision.

2.20/ Temporary Concrete Barriers -- Example 1

The Contractor shall place precast concrete barriers for the protection of traffic as shown on the staging drawings.

After completion of each construction stage, the Contractor shall relocate the barrier to the new location shown on the staging drawings.

The Contractor shall place, relocate and remove the concrete barriers during the off-peak traffic periods as noted under Operational Constraints.

The Contractor shall maintain drainage under the temporary barrier at all times.

The concrete barrier shall remain the property of the contractor and shall be removed by him from the site at his cost after completion of the required work .

Placing of Day-Night Reflectors

The Contractor shall supply, install and maintain Retro Reflectors on top of the concrete barrier. The reflectors will be anchored on every second concrete barrier section (4 m length) at 8 m centres.

The reflectors shall remain the property of the Contractor.

Placing of Plywood Under Barrier*

The Contractor shall place 11 mm plywood sheets (two sides rough) between the completed surface course of Stage 1 and the concrete barrier. The plywood sheets shall be 2440 mm long and 600 mm (nominal) wide. At the end of the barrier installation, the last sheet shall extend by 600 mm beyond the barriers.

The plywood shall remain the property of the Contractor and shall be removed by him from the site.

Payment**

Payment at the contract price shall be compensation in full for the supply of all labour, equipment and material to complete the work of this item. Payment will be made as follows:

75% for supply and erection of Stage 1;
15% for relocation to Stage 2; and
10% for removal of precast concrete barrier.

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* Plywood is only used when the barrier is placed on new asphalt.

** This method is used for lump sum payments. The breakdown shown will require adjustment when there are other than two stages.

2.21/ Temporary Concrete Barrier -- Example 2

The Contractor shall place precast concrete barrier for the protection of traffic as shown on the contract drawings.

After completion of each construction stage, the Contractor shall relocate the barrier to the new location shown on the contract drawings.

The Contractor shall maintain drainage under the temporary barrier at all times.

The concrete barrier shall remain the property of the Contractor and shall be removed by him from the site after completion of the required work at his cost.

Placing of Day/Night Reflectors

The Contractor shall supply, install and maintain Retro Reflectors on top of the concrete barrier. The reflectors shall be anchored on every second concrete barrier section (4 m length) at 8 m centres.

The reflectors shall remain the property of the Contractor.

Measurement and Payment*

Measurement will be made in linear metres of barrier placed where required in the contract drawings, and both the original location and any relocation shall be measured. Payment at the contract price shall be compensation in full for all labour, equipment and material required to complete the work.

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* Used when item is not bid as lump sum.

Insert "Placing of Plywood Under Barrier" as shown in Example 1 when required.

2.22/ Weld and Release Manhole Frames and Grates

The Contractor shall weld the existing frames and grates, exposed to traffic, throughout the contract. Location and length of the welds are as shown on the contract drawings.

Reference:

CSA W59.1 -- 1970 General Specifications for Welding of Steel Structures
(Metal Arch Welding)

Payment at the contract price for the above item, shall be full compensation for the supply of all labour, equipment and material necessary to weld, maintain and release the welded frames and grates.

This special provision is normally the responsibility of the Regional Planning and Design Section.

2.23/ Cold Plane Concrete Pavement

Payment at the contract price for this tender item, shall be compensation in full for all labour, equipment and material necessary to cold plane the concrete pavement, where, and as shown on the contract drawings and to the depth as indicated. The concrete material shall be removed and disposed of outside the right-of-way.

This special provision is normally the responsibility of the Regional Planning and Design Section.

3/ STANDARD SPECIAL PROVISIONS

3.1/ Introduction

Standard special provisions which may be required as part of a bridge deck rehabilitation contract are listed in Section 3.2. The text of each special provision and the warrant for its use can be found in the Contract Design Estimating and Documentation Manual and the P Q P Supplement. Each one should be reviewed at the time of design to ensure that it is suitable for any specific contract.

3.2/ List of Standard Special Provisions

SP No.	Item Description or Title of Special Provision
112	Supply and Delivery of Asphalt Cement
114	Placing Hot-Mix Pavement Before and After Hot-Mix Paving Operations are Prohibited due to Temperature Restrictions
117	Metric Conversion of Steel Reinforcement
118	Metric Conversion of Classes of Concrete
120.01	Portland Cement Concrete Alkali-Silica and Alkali-Carbonate Reactive Rock
120.02	Portland Cement Concrete Low-Alkali Portland Cement
123	Prolonged Storage of Hot-Mix in Silos
137	Extra Work
139	Slay Cement
150	Construction Staging
151	Protection of Public Traffic
152	Night Work
185	Structural Reference Plans
186	Operational Constraints
189	Alteration of Construction Elevations
190	Reinforcing Steel
190.01	Concrete Mix Proportions
190.03	Testing of Joint Assembly Installations
191	Rotational Bearings
192	Amendment to Form 914 Asphalt Membrane Waterproofing
194	Stay in Place Forms
301	Hot-Mix HL 1, 2, 3, 4 Cancellation of the Surface Course Trial Area

List of Standard Special Provisions (cont'd.)

SP No.	Item Description or Title of Special Provision
304	Hot-Mix HL 1, 2, 3, 4, 8 Automatic Screed Controls
316	Hot-Mix HL 1, 2, 3, 4, 8 Hot-Mix HL 1, 2, 3, 4, 8 Patching Hot-Mix HL 4, 8 Modified Open Friction Course Mix Dense Friction Course Mix Asphalt Treated Base Electrically Conductive Mix Frozen Roadbed Tarpaulins
317	Hot-Mix HL 1, 2, 3, 4, 8 Anti-Stripping Additives
318	Cutting Existing Pavement
321	Dense Friction Course Mix
504	Temporary Concrete Barrier Precast Concrete Barrier
520	Traffic Control Contractors Supply of Construction Signs
564	*Temporary Concrete Barrier
905	Bridge Deck Waterproofing Temperature Restrictions
907	Bridge Deck Waterproofing Contractors Option
909	Concrete in Deck Bridge Decks Mechanical Finishing
952	*Bridge Deck Waterproofing Modification of Deck Drains
954	*Reinforcing Steel
955	*Steel Barrier Rail Pedestrian Handrail
956	*Supply and Install Joint Assemblies Modification of Deck Expansion Joints

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*When these tender items require Plan Quantity Measurement.

4/ LIQUIDATED DAMAGES SPECIAL PROVISIONS

4.1/ Introduction

The following special provisions represent current Ministry practice with regards to defining a working day. These special provisions are inserted by the Contract Preparation and Control Section. They are provided here as reference material to enable the Project Engineer to have a better understanding of the process of setting the number of working days.

The first example represents a normal working day as defined in a Ministry contract. The second example defines a working day as a shift. In the second example the contractor would be charged at the rate of 11 shifts per calendar week.

4.2/ Normal Working Day

LIQUIDATED DAMAGES

1/ Time

Time shall be the essence of this contract.

2/ Progress of the Work and Time for Completion

The charging of working days shall commence on and the contractor shall diligently prosecute the work on this contract to completion on or before the expiration of working days from the date of commencement.

If the time limit above specified is not sufficient to permit completion of the work by the Contractor working a normal number of hours each day or week on a single daylight shift basis, it is expected that additional and/or augmented daylight shifts will be required throughout the life of the contract to the extent deemed necessary by the Contractor to insure that the work will be completed within the time limit specified. Any additional costs occasioned by compliance with these provisions will be considered to be included in the prices bid for the various items of work and no additional compensation will be allowed therefor.

Working time shall be charged until the date of acceptance of the work by the Ministry at which time all work required in the contract, including all final clean-up and trimming shall be completed.

3/ Controlling Operation

A controlling operation or operations is any feature of the work as determined by the Engineer, which, if delayed, will delay the time of completion of the contract.

4/ Working Day

A Working day is defined as any day:

a/ except Saturdays, Sundays and Statutory Holidays;

b/ except a day as determined by the Engineer, on which the Contractor is prevented by inclement weather or conditions resulting immediately therefrom, from proceeding with a controlling operation;

For the purpose of this sub-section, this will be a day during which the Contractor cannot proceed with at least 60% of the normal labour and equipment force effectively engaged on the controlling operation for at least 5 hours.

c/ except a day on which the Contractor is prevented from proceeding with the controlling operation, as determined by the Engineer, by reason of:

i/ any breach of contract or prevention by the Ministry, by any other Contractor of the Ministry or by any employee of any one of them;

ii/ non-delivery of Ministry supplied materials;

iii/ any cause beyond the reasonalbe control of the Contractor as substantiated by him to the satisfaction of the Engineer;

d/ except any day from to inclusive, even though the Contractor may elect to carry out any approved work as called for under this contract during this period.

The Engineer will furnish to the Contractor for his signature a weekly "Statement of Record of Working Days". The Contractor will be allowed two weeks in which to file a written protest setting forth in what respects the said weekly statement is incorrect, otherwise, the statement shall be deemed to have been accepted by the Contractor as correct.

5/ Liquidated Damages

It is agreed by the parties to the contract that in case all the work called for under the contract is not finished or completed within the number of working days as set forth in the special provisions or as extended in accordance with Sub-section 107-2 of MTC Form 100, a loss or damage will be sustained by the Ministry. Since it is and will be impracticable and extremely difficult to ascertain and determine the actual loss or damage which the Ministry will suffer in the event of and by reason of such delay, the parties hereto agree that the Contractor will pay to the Ministry the sum of $ as liquidated damages for each and every calendar day's delay in finishing the work in excess of the number of working days prescribed. It is agreed that this amount is an estimate of the actual loss of damage to the Ministry which will accrue during the period in excess of the prescribed number of working days.

This special provision will be added by the Contract Management Office.

4.3/ Accelerated Work Schedule

Progress of the Work and Time for Completion

The three paragraphs under this heading in 4.2 shall be deleted and replaced with the following:

The charging of working days shall commence on   and the Contractor shall diligently prosecute the work on the contract to completion on or before the expiration of   working days from the date of commencement.

If the time specified above is not sufficient to permit completion of the work by the Contractor working the shifts specified below, it is expected that augmented labour and equipment forces will be required throughout the life of the contract to the extent deemed necessary by the Contractor to insure that the work will be completed within the time limit specified. Any additional costs occasioned by compliance with these provisions will be considered to be included in the prices bid for the various items of work and no additional compensation will be allowed therefor.

Working time shall be charged until the date of acceptance of the work by the Ministry at which time all work required in the contract, including all final clean-up and trimming shall be completed.

Working Day

The portion of the Special Provisions under this heading shall be deleted and replaced with the following:

A Working Day is defined as each of the following 12-hour periods of time (shifts)

1/ 0700 hr to 1900 hr;

2/ 1900 hr to 0700 hr;

a/ except 1900 hr Saturdays to 0700 hr Mondays and 1900 hr the day preceding Statutory Holidays to 1900 hr on the Statutory Holiday,

b/ except a shift as determined by the Engineer, on which the Contractor is prevented by inclement weather or conditions resulting immediately therefrom from proceeding with a controlling operation,

For the purpose of this Sub-section, this will be a day during which the Contractor cannot proceed with at least 60% of the normal labour and equipment force effectively engaged on the controlling operation for at least 5 hours.

c/ except a shift on which the Contractor is prevented from proceeding with the controlling operation, as determined by the Engineer, by reason of:

i/ any breach of contract or prevention by the Ministry, by any other Contractor of the Ministry or by any employee of any one of them,

ii/ non-delivery of Ministry supplied materials,

iii/ any cause beyond the reasonable control of the Contractor as substantiated by him to the satisfaction of the Engineer.

This special provision will be added by the Contract Management Office.

5/ REFERENCE CONTRACTS

5.1/ Patch, Waterproof and Pave

Contract	Region	Hwy	Structure	Other Repairs
82-217	N	11	ONR Overhead	Joints, New Barrier Walls, Pier Repairs, New Approach Slabs
		624	Blanche R. Bridge	Joints
83-29	C	7	Indian R. Bridge	New Barrier Walls
83-43	C	QEW	Lyons Ck. Bridge	New Barrier Walls
83-227	N	17	Veuve R. Bridge	Joints, Adjust Bearing
		539	Deer Ck. Bridge	Joints
		64	Wolseley R. Bridge	Joints
83-304	E	401	St. Hilaire Rd. U-P	Joint Modification
		401	Mitchells Rd. U-P	Joint Modification
		62	Rawdon Ck. Bridge	Joint Modification

5.2/ Cathodic Protection

82-40	C	12	Atherley Narrows Bridge	Joints
83-22	E	417	Clyde Ave O-P	Barrier Walls, Bearing Shotcrete Repairs, Painting, Approach Slabs
			Carling Ave E.B. and W.B. O-P	
			Kirkwood Ave O-P Island Pk O-P	

5.3/ Concrete Overlays

5.3.1/ Low-Slump

Contract	Region	Hwy	Structure	Other Repairs
80-351	C	28	Trout Ck. Bridge	Joints

5.3.2/ Latex-Modified

82-57	S.W.	Hwy 6 N.	Speed R. Bridge	Joints
82-79	C	28	Ottonabee R. Bridge at Youngs Point	Joints, Bearings
82-102	C	427	Hwy 5 O-P	Joints
83-34	C	QEW	Fifty Rd.	Joints
			North Service Rd. over Sixteen Mile Ck.	Joints

5.3.3/ Concrete Overlay, Patch, Waterproof and Pave

82-57	S.W. 67	6,7,86	Homer Watson O-P	Joints
			Ottawa St. O-P	Joints
			University Ave U-P	Joints
82-87	C	27	Humber R. Bridge at Kleinburg	Soffit Repairs
82-102	C	427	CPR Overhead North Queen St. O-P	
			N.B. Collector Basketweave	Joints
83-22	E	417	Merivale Rd. O-P	New Barrier Walls, Shotcrete Repairs

POOR

QUALITY

ORIGINAL